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NEWSLETTER

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THE EVOLUTION OF ANUPAM SUPERCOMPUTERS

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Computers have become ubiquitous in all walks of scientific endeavour. There have been innumerable architectures of computers, aiding equally countless, diverse fields of research, thereby rendering the task of classification of computers itself a nontrivial job. Interestingly, this gamut of computers are classified neither by their explicit features nor by the class of application to which they cater to, but by the way the

data and instruction streams flow through them. Specifically, this classification identifies whether there is single stream or multiple streams of data and instructions, which flow through them. Thus, we have Single Instruction Single Data (SISD), Single Instruction Multiple Data (SIMD), Multiple Instruction Single Data (MISD) and Multiple Instruction Multiple Data (MIMD) categories of computers.



Fig. 1: Anupam-Ajeya delivers a sustained performance of 9 teraflops

The conventional sequential machines belong to the SISD category. To speed up computations in SISD machines, one has to either speed up instruction processing (use faster processors) or push data around at a faster rate (use faster system bus, memory, cache etc.) or employ both methods. But their speeds are limited by the hardware technology at that given point of time and the improvements too will depend upon technology development and hence, performance gain will also be incremental in nature. Everything being equal, if one has to derive large performance gains, then one will have to make use of multiple processors, working on multiple sets of data, interconnected through some medium. Machines with specialized functional units, to process multiple chunks of data concurrently (Processor Arrays, Vector Processors) belong to the category of SIMD. In this architecture, the same instruction is executed concurrently over multiple datasets, in lock-steps. This is suitable only for very specific type of applications. MIMD is another interesting architecture wherein, multiple processors execute different instructions on different sets of data independently and yet work in unison, to solve a single problem. This architecture has come to be known as parallel processing. Parallel processing has emerged as the defacto method of achieving performance, that is of greater orders of magnitude than the one that is obtained by single computer at any given point of time. This is the most flexible architecture among the four categories of computers. All modern parallel supercomputers fall in this category. For the sake of comprehensiveness, we can state that there have been only a couple of MISD class of machines and these have remained of academic interest only.

About fifteen years ago, the development of the Anupam Series of Parallel Supercomputers was started with the goal of achieving computing speeds that were ten times more than the speed of the sequential machines available at that time. BARC has a large pool of Scientists and Engineers working in various

aspects of Nuclear Science and Technology and whose computational needs are diverse in nature. To cater to the computational needs of this diverse set of users, it was decided to build a general-purpose parallel computer, rather building many application-specific clusters. To keep the gestation period short, it was decided to build the parallel computer with commercially available off-the-shelf components, with our major contribution being in the areas of system software development, application software development, system engineering, system integration and fine tuning of the system.

The performance of a parallel processing system, essentially depends upon the processor speed and the performance of the interconnect, that glues the participating processors. Earlier versions of ANUPAM systems were based on bus-based (Multibus-II) architecture and i860 processors. This was indeed a simple design, wherein all the processors were latched on to the Multibus-II bus. To initiate the communication, the sender had to gain control of the bus and then send the data to the receiver. Using the ANUPAM systems based on this architecture, a large number of research problems from various domains were resolved (Molecular Dynamical Simulations, Reactor Physics, Theoretical Physics, Computational Chemistry, Computational Fluid Dynamics, Finite Element Analysis to name a few).

As the resolutions of the computational models increased and the models themselves became far more complex, the amount of data that needed to be transferred across also became very huge. This architecture was found wanting as it could not cater to the newer demands. As mentioned previously, in the bus-based architecture, one had to gain control of the bus to perform the data transfer. As only one processor could be the bus master at a given point of time and perform the data transfer, the other processors had to wait to gain control of the bus, even though

they had completed their computations and were ready to effect the data transfer. This meant, that even though the computations were done in parallel, the communications remained sequential in nature and hence the turnaround times of the programs did not improve. With the result, these complex, high-resolution models did not scale appreciably.

The issue was to effect the communication that had remained sequential in nature, to parallel. There were two alternatives. The first one was to make use of multiple busses, each of which interconnected a given set of processors. The communication in these multiple busses could go in parallel. The second alternative was to go in for the switch-based architecture wherein, the communications could proceed in parallel, in machines connected to different ports of a switch; the limiting factor being the switching speed of the backbone fabric of the switch. With this, the communication could be carried out in truly parallel manner. This design has come to stay as the typical interconnect model for ANUPAM series of parallel supercomputers. A parallel supercomputer based on Asynchronous Transmission Mode (ATM) interconnect was built in 1997.

With substantial improvement in the performance of PC-based workstations and developments in LAN technologies, building High Performance Computing (HPC) cluster, using these state-of-the-art commodity components, became a very cost-effective approach. We have built quite a large number of clusters using PC-based workstations as compute nodes and commodity Fast and Gigabit Ethernet switches as interconnection networks. Anupam-Ashva, a 64-node system, Anupam-Alpha which replaced CRAY XMP216 at NCMRWF, Mausam Bhavan, NewDelhi, Anupam-Ameya, a 512 processor cluster that delivered 1.73 Teraflops of sustained performance to name a few. Insofar as the interconnects are concerned, the factors that govern their efficacy in parallel processing are the Bandwidth of the point-to-point links and the latency in sending messages from one system to

another, in the network.

With ever increasing processor speeds, LAN technologies like Fast and Gigabit Ethernet that are conventionally used as cluster interconnects are fast becoming inadequate, in extracting the full potential of the cluster. To cater to the specific demands of High Performance Computing (HPC) cluster interconnects, there is a growing breed of new interconnect technologies called System Area Networks (SANs). These new technologies incorporate characteristics such as high bandwidth, low latency for communication and scalability to a large number of nodes, that are very essential for HPC cluster interconnects. LAN technologies are aimed primarily at providing connectivity among computers spread across geographical distances of a few kilometers. Whereas SAN technologies are restricted in geographical scope with spanning distances of only up to a few meters, suitable for networks within a system. The various SAN technologies available today include InfiniBand, Myricom Myrinet, Quadrics QsNet, QsNetII and Dolphin SCI. Myrinet and QsNet are proprietary technologies whereas SCI and InfiniBand are industry-standard interconnect architectures. We have used both SCI and InfiniBand SAN technologies as cluster interconnects in ANUPAM systems.

SCI (Scalable Coherent Interface)

This is an interconnect standard (IEEE 1596) for high performance networking which aims to provide high bandwidth, low latency and low cpu overhead for communication operations. An SCI interconnect is defined to be built only from unidirectional point-to-point links between participating nodes. This feature of the SCI links makes it possible to achieve high bandwidths. In contrast to a LAN, the SCI provides hardware-based physical Distributed Shared Memory (DSM), thus exhibiting some characteristics of a Non Uniform Memory Access (NUMA) machine. Because of this architecture, internode communication translates into simple CPU load and stores into DSM

segments, which are mapped from remote node memories. Hence, there is no need for a protocol stack, which results in low latencies for communication. The SCI standard, specifies a bandwidth of 1 GB/s but current implementations achieve a link speed of 667 MB/s. SCI clusters can have many topologies such as ring, switch and torus. We have used SCI as an interconnect technology in our 64-node, 128 CPU ANUPAM-ARUNA cluster with an 8x8, 2-D torus topology. This delivered a sustained performance of 365 Gflops.

InfiniBand Architecture

InfiniBand is an industry-standard specification, that defines input/output architecture used to interconnect servers, communication equipment, storage and embedded systems. The InfiniBand specification is defined and maintained by the standards organization InfiniBand Trade Association (IBTA), an industry consortium of hardware and software vendors. When IBTA was formed in 1999, the primary goal of InfiniBand was to replace the PCI bus. Over a period of time, positioning of InfiniBand evolved from being a PCI replacement to being an HPC interconnect for high-speed I/O, networking and inter-process communication.

InfiniBand is a point-to-point, switched fabric, serial I/O interconnect architecture, that can be used for backplane solutions (intra-box) as well as for providing external (inter-box) systems interconnects. It is a low-latency, high-bandwidth interconnect which requires low processing overhead and is ideal for carrying multiple traffic types (clustering, communications, storage, management) over a single connection.

The communication is full duplex and the InfiniBand specification defines 3 link widths, 1x, 4x and 12x. The basic 1x link consists of one high-speed transmission line in each direction (4 wires for bidirectional communication) with a signalling rate of 2.5 Gbps Single Data Rate (SDR). InfiniBand supports

double data rate (DDR) and Quadruple Data Rate (QDR) speeds, that is, 5 Gbps and 10 Gbps respectively, at the same clock rate. Infiniband uses 8b/10b encoding. This yields a net data rate of 250 MByte/s per direction (SDR). Links with 4x and 12x widths are multiples of 1x link and accomplish raw data rates of 10 Gbps and 30 Gbps (SDR). A raw data rate of 120 Gbps can be accomplished with a 12x QDR link. Table1 shows the raw data rates in InfiniBand for various link widths and signalling rates. Maximum packet payload is 4 KB. As a medium,

Table 1: Raw data rates in InfiniBand

Data Rates	1x	4x	12x
SDR	2.5 Gbps	10 Gbps	30 Gbps
DDR	5 Gbps	20 Gbps	60 Gbps
QDR	10 Gbps	40 Gbps	120 Gbps

InfiniBand defines various copper and fiber-optics cables. A maximum length of 17 meters (SDR, 10 meter for DDR) is specified for copper cable and up to 200 meters for fiber-optic cable.

The latency measured at MPI level is usually 3 to 4 microseconds. An important feature of InfiniBand Architecture that reduces the application level latency and CPU overhead is the support for Remote Direct Memory Access (RDMA). With traditional networks such as Ethernet, the communication between applications is relatively cumbersome. Incoming data is accepted by the network card, processed in the kernel of the operating system and finally delivered to the application. As part of this, data is copied repeatedly from one buffer to the next. Furthermore, several process changes are necessary in the operating system. All this costs CPU cycles and places a load upon the system bus, thus reducing the communication throughput and increasing its latency.

Remote Direct Memory Access (RDMA) is a communications technique, that allows data to be transmitted from the memory of one computer to the memory of another computer, without passing through either CPUs, without needing extensive buffering and without calling to an operating system kernel. When an application performs an RDMA Write request to the memory on the remote system, the RDMA request is issued from an application running in user space, to the local Network Interface Card (NIC). The "RDMA Engine" on the NIC uses DMA to read data from the user-specified buffer and transmits it as a self-contained message across the network. The "RDMA Engine" on the receiving NIC then uses DMA to place data into the user-specified memory location. There is no intermediary copying and all these operations occur without the involvement of the CPUs

reducing the latency and CPU overheads. We are using the InfiniBand technology as the cluster interconnect, in the latest Anupam-Ajeya Supercomputer.

ANUPAM-Ajeya Supercomputer

ANUPAM-Ajeya is the latest in the series of Anupam parallel supercomputers. It deploys 1152 processor cores as its computational workhorses, delivering a sustained performance of 9 teraflops. It is based on the concept of Cluster of Workstations. It is a compact, centralized, homogeneous Linux cluster, comprising of 288 dual-core, dual-processor nodes, interconnected by InfiniBand as well as Gigabit Ethernet networks. A logical view of ANUPAM-Ajeya architecture is shown in Fig. 2.

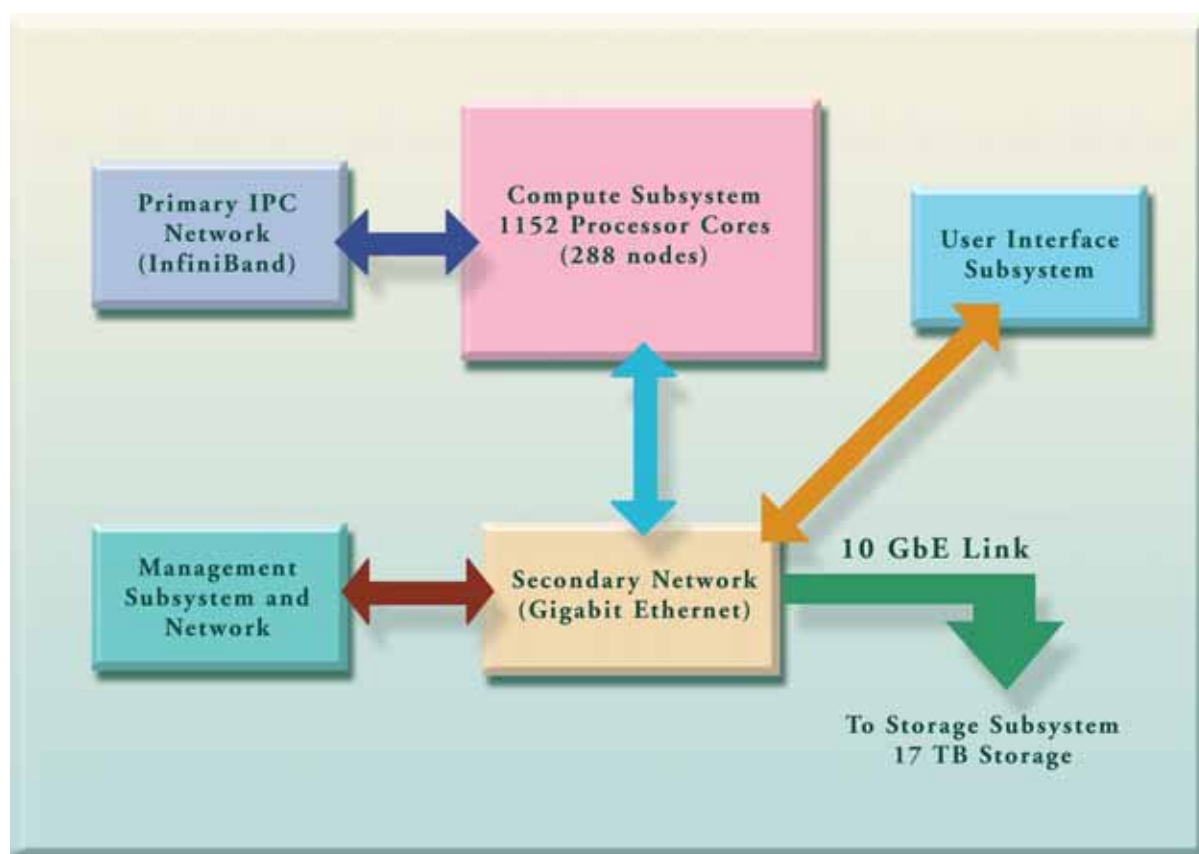


Fig. 2: Block diagram of ANUPAM-Ajeya architecture

The ANUPAM-Ajeya Supercomputer consists of the following subsystems:

Compute Subsystem

The Compute Subsystem is the major subsystem of a Supercomputer, which defines the performance of the system. This subsystem consists of Dual Core Dual Xeon systems with 1U form factor as compute nodes, leading to a total of 1152 CPU Cores. Each node has 4 GB memory, a PCI Express x8 slot and 2 Gigabit Ethernet ports. The Operating System on all the nodes is Scientific Linux 5 and parallel programming environment is provided by MPICH, MPICH2, OPENMPI, PVM and our in-house ANULIB libraries.

Interconnect Subsystem

The system has two interconnect networks, the primary Inter Process Communication (IPC) network is an InfiniBand SAN (System Area Network) and the secondary one is a Gigabit Ethernet Network. The InfiniBand SAN comprises of a 288 port, 4x DDR (20 Gbps), InfiniBand switch interconnecting the 288 compute nodes using the InfiniBand Host Channel Adapter (HCA) cards (installed on the PCI Express x8 slot on each node) and InfiniBand copper cables. The Gigabit Ethernet Network consists of six 48-port and two 24-port Gigabit Ethernet switches, stacked to form a 336-port switch. All the switches are powered through UPS. This Gigabit Network is connected to the Storage Subsystem using 10 Gbps Ethernet link.

The InfiniBand SAN is used explicitly for inter-process communication, whereas the Gigabit Network is used mainly for accessing the file servers over NFS and for the data traffic pertaining to cluster monitoring and management activities. The Gigabit Network can also be used as a secondary inter-process communication network.

Management Subsystem and Network

Each node in the cluster is equipped with an IPMI (Intelligent Platform Management Interface) Card. IPMI is used for remote management and monitoring of the nodes. Using IPMI, SOL (Serial over LAN) is configured to access the console and BIOS of the nodes over the LAN port, avoiding the wiring for serial ports or KVM switch.

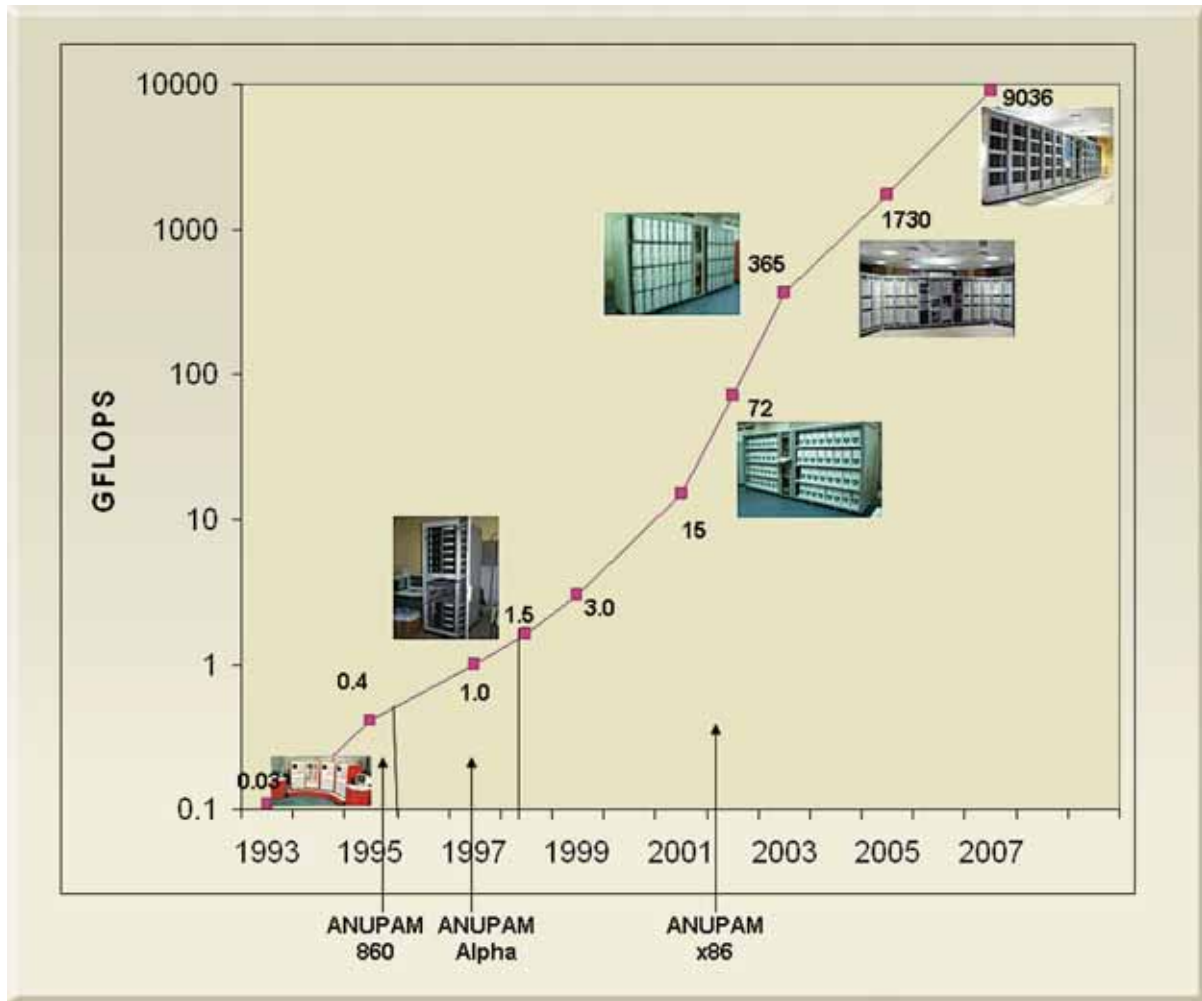
All the Gigabit switches and compute nodes are powered through Power Distribution Units (PDU) in order to control the power to the devices through software, i.e. starting in sequence (in order to prevent sudden surge of current at system startup), selectively powering ON/OFF or resetting the device. These PDUs are connected using a dedicated management network comprising of Fast Ethernet Switches. This network is connected to the secondary network using a Layer 3 switch and VLAN technology.

User Interface Subsystem

This subsystem consists of user terminals to which users can log in directly or through intranet, to compile, submit and monitor their jobs.

Storage Subsystem

All ANUPAM systems (namely, Anupam-Ajeya, Anupam-Ameya and Anupam-Ashva) installed at the Supercomputing Research Facility building share a common storage Subsystem in order to enable users to seamlessly use all the clusters. The Storage Subsystem consists of file servers, backup servers and tape libraries.



File Servers: There are 12 file servers, which constitute 17 terabytes of storage space. Each server is a 2U rack-mount server, equipped with dual processors.

servers are programmed to take periodic backup of file servers to their local disk and then copy it on to the tape library.

Backup Servers: There are two backup servers for taking backup of users' data. Each server is a 5U rack-mount server equipped with dual processors and backup devices like DVD writer, DAT and DLT drives. Besides that, each server is connected to a tape library. The backup servers offload the backup load from the main file servers.

Design challenges for the storage subsystem are performance, reliability and availability. Necessary redundancy is provided to reduce failures and downtime. Moreover, system design ensures minimal effect on services in case of a server failure. RAID is configured on each server to overcome single disk failures. Each server has three Gigabit Ethernet network ports, which have been link-aggregated to increase the availability and throughput three fold. The users are distributed across the 12 file servers so that a single

Tape Libraries: There are two tape libraries with a storage capacity of 3.2 terabytes each. The backup

server failure affects only a fraction of users while others can still continue to use the system.

System Layout

The layout of the ANUPAM-Ajeya system is planned in such a way, that it ensures efficient cooling and optimal use of space, without obstructing future repairs and maintenance. The whole system is housed in 12 racks of height 42U, closely aligned in a straight line. Ten racks house compute nodes, each of which contains 28 nodes and four PDUs arranged in 4 groups of 7 nodes each. The nodes within a group are tightly stacked without any gap. There is a 2U gap across the groups to accommodate lengthy cables. We have sealed the gaps on the front side with blanking panels to prevent cold air from escaping through the gaps. Two racks that contain switches, UPS and the 8 service nodes are placed in the centre for symmetry and for reducing the cable lengths.

The Ethernet cables are routed from the top of the racks and the InfiniBand cables that are heavy in weight, are routed from the bottom of the racks. All cables are properly laid through the ducts at the backside corners of the rack, so that, they do not obstruct the airflow. Cold air is provided through gridded tiles in false flooring, right in front of the racks, to ensure proper cooling.

Performance Measurement / Benchmarking

Performance of a Parallel System is measured in terms of GigaFLOPS (GFLOPS) or TeraFLOPS (TFLOPS), where FLOPS stands for Floating point Operations Per Second. When performance is calculated using the CPU's clock frequency and average Cycle Per Instruction (CPI) rating, it gives *peak performance* of the system. Where as, the *sustained performance* of a system is measured by running benchmarks or real programs on actual machines. In this case, the true performance of a computing system involving the processor, the memory, the peripheral devices and the interconnects

as an integrated unit will be measured.

Most of the published GFLOPS and TFLOPS results are based on running LINPACK benchmark code. LINPACK is a general purpose Fortran library for solving dense system of linear equations. We have used a High Performance LINPACK (HPL) benchmark to evaluate the performance of the ANUPAM-Ajeya system. HPL is run for a matrix size of 3,40,000 X 3,40,000 on 1152 cores of Ajeya system and it gave a sustained performance of 9.036 TeraFLOPS. The performances of the various Anupam Systems, developed over the past 15 years, have been depicted in Fig. 3.

Issues in deploying a cluster in production environment

Building a cluster with novel features, that caters to a given application, is entirely different from building a cluster that will have to go into a production environment. It needs to be run on round-the-clock basis throughout its lifetime, catering to a wide variety of applications. Furthermore, when a cluster is relatively small, (say <32 nodes) its installation, management, monitoring and archival taking corrective action on degradation of environmental conditions and troubleshooting, can be carried out manually. But when the cluster size grows to encompass a large number of components (few hundreds of processors/disk drives, scores of PDUs, scores of Terminal concentrators, scores of switches, file servers and their associated cooling components), automation becomes a necessity for monitoring their health. The total number of components that needs to be monitored for ANUPAM-AJEYA is about 3000. It goes without saying that other operational tasks like installation, configuration management, job scheduling, accounting of system utilization, archival, power-recycling of given node/ nodes etc. of this large cluster, need to be automated. All these tools have been developed in-house and have been deployed in production clusters.

AnuInstall

One of the important tasks in setting up a cluster, is software installation on nodes and servers and configuring them according to their roles in the system. For a large cluster, having hundreds of nodes, it is a very tedious (and also error-prone) process if one has to install and configure each and every node manually, as it involves several tasks like partitioning of hard disks, selection of appropriate system packages, configuration of network and several post installation tasks like configuration of required services, installation of compilers and other required packages, etc. Therefore, there is a need of an automated installation tool to perform the above tasks in an absolutely error-free manner. For this purpose, *AnuInstall* has been developed.

Various computing elements in Anupam-Ajeya have been categorized into four groups depending on their functionalities namely compute nodes, storage servers, service nodes and backup nodes. ANUPAM-Ajeya has 280 Compute Nodes, 12 Storage Servers, 8 Service Nodes and 2 Backup Servers. Computers belonging to each of these categories would require different configuration detailing. For the automated installation and configuration of these nodes, we have developed AnuInstall tool in-house. This tool uses network installation feature of Linux using PXE LINUX. However, this tool does not keep a separate copy of the kickstart file for each node; instead it generates the kickstart file of the node by a CGI script based on the node's IP address and hostname. The kickstart file is requested using HTTP and the web server runs CGI scripts to generate the kickstart file based on the requesting IP and the configuration is stored in the database. Based on IP address, hostname is resolved and on basis of the hostname, closest matching template of options is selected. List of services to be run is also generated based on the hostname. At the end of the installation, a log file of installation is uploaded on the central server for checking successful installation. An email is

also sent to the administrator when installation is completed.

Installation of new nodes is a bit tricky because the mapping of the node's MAC address to its IP address is not known. For this, installation is done in two steps. In the first step, a minimal OS installation is done and hostname to MAC address mapping is registered and in the second step complete OS with full configuration is installed.

Monitoring and Management Tools

For cluster monitoring and management, we have developed the monitoring tool *Anunetra*. Monitoring the nodes, reporting errors, generating alerts and facilitating centralized management are its major functions. In general, it provides centralized interface to perform health check activities in the cluster and other basic management tasks.

Anunetra continuously monitors Ajeya system and reports errors in case of any deviation from normal operating values. Metrics like CPU temperature, fan speed, disk usage, CPU usage, CPU count, CPU speed, swap used, memory free, bytes in/out, packets in/out etc. are under continuous monitoring. The management interface of Anunetra allows the administrator to perform some common tasks, like making the nodes offline/online, network connectivity check, services check, available disk space, etc.

Anunetra uses the publisher and transport mechanism of Ganglia (a public domain utility software). Other modules such as collection, archiving and presentation are designed according to our needs and constraints. Other than common monitoring features, it incorporates facilities such as Reports, Analysis, Alert System, Auto Restart of failed nodes, Resource and Job Information, Management Interface and so on.

Recently, an *Environment Monitoring tool* has been developed, to monitor the temperature and

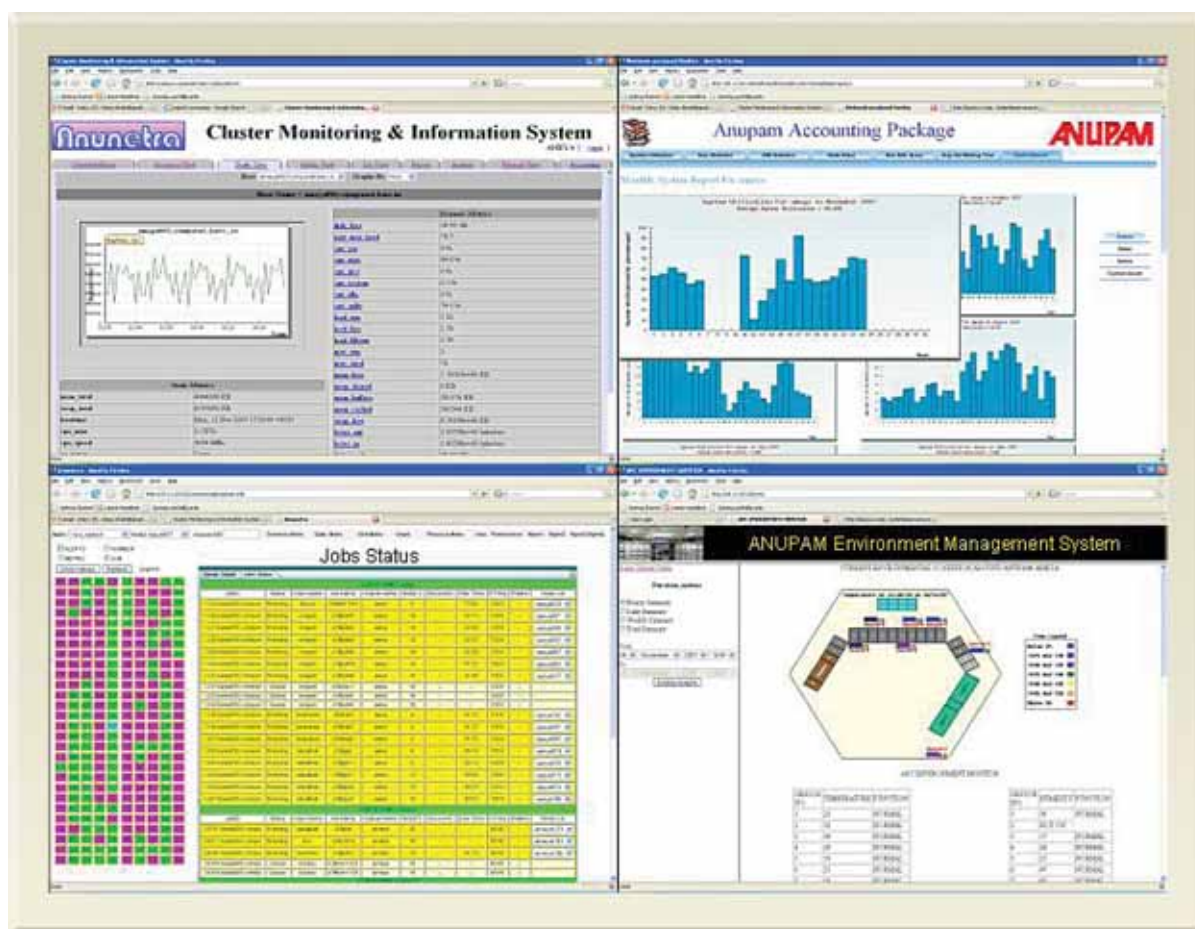


Fig. 4: Snapshots of various monitoring tools in Anupam Systems

humidity around a large cluster. For the implementation of the system, six temperature and humidity sensors are deployed at various positions of the cluster to monitor temperature and moisture present in the air. These sensors are connected to Environment Management module, which provides sensors' data on the network. The central monitoring program polls the Environment Module Manager using SNMP to collect data for all the sensors. These values are then compared with preset threshold values and SNMP trap is generated. Trap handler, running on a remote machine on operator's desk, switches on an audio hooter to alert the operator on duty. This may be well appreciated when we note, that only a few operators manage a large number of clusters, housed

in different buildings on our huge campus, on a round-the-clock basis. These operating personnel who manage multiple sites reside at a central place during silent hours.

Job Management System

To manage jobs on the Ajeya cluster, we have Job Management System, which is based on TORQUE Resource Manager and MAUI Job Scheduler. These tools are complemented by augmenting them with in-house developed codes as per our needs. User jobs have different types of resource requirements namely, some jobs need a large number of processors whereas

some saturate at a small number of processors, some jobs run for one or two days whereas some last up to a week, some jobs have to run on some subset of nodes due to software licenses binding and so on. Considering all these requirements, different job-queues are provided with different scheduling and execution policies for each.

Based on demand and available resources, the Scheduling Policy for jobs in Ajeya is optimized. It is designed to avoid resource starvation for large jobs and better utilization of the available resources. Throttle limit for scheduling maximum jobs per user at a time is set and fair-share policy provides a fair portion of the cluster's resources to each user, under heavy load conditions. The Scheduler schedules two jobs per user at a time, but during heavy load, it dynamically decides jobs per user, based on historical data of previously executed jobs.

Accounting Tool

We have developed an Accounting Tool to get information about Ajeya's utilization. One can find system utilization (current as well as previous day's/ week's/ month's), users' statistics, current status of the nodes, status of current jobs, etc., using this tool. It has a centralized database that records the information about each and every job submitted to the cluster. Database is populated by data-entry programs, installed on all the compute nodes, which are invoked on submission, startup and termination of jobs. Job parameters such as username, job-name, number of nodes demanded, parallel API used, job's start and end times, are recorded in the accounting database.

To generate meaningful reports out of the collected data, an interactive web interface has been made available, using which, one can extract and display the following information in tabular as well as in graphical form.

- Daily and monthly reports of utilization of individual nodes as well as whole cluster
- Daily and monthly reports of user wise system utilization
- Cluster wise quick reports for getting cluster utilization of the past twelve months in one go
- Average waiting time of a job in a queue.

AnuSakshi

There are a large number of components in Ajeya System like Compute Servers, File Servers, Network Switches, PDUs, UPS, etc. each having a number of subcomponents like Hard disks, Processors, Power supplies, etc. It is difficult to manually keep track of all faults and maintenance operations done on these components/ subcomponents. Therefore, AnuSakshi was developed to automatically log all these events and maintain a history of these events along with remarks explaining the events.

AnuSakshi is used to derive the performance of the system and get the availability of the whole system or a component at any given time. It also keeps track of all the faults occurring in any component and the corresponding maintenance operations carried out to rectify them and also the corresponding change of status of components arising or movement of components taking place between BARC and vendors. It also generates a list of the most faulty nodes along with their corresponding number of failures.

Applications

The ANUPAM computers have been extensively used in-house to develop compute-intensive applications such as Ab-Initio Molecular Dynamics, Monte Carlo simulations, Finite Element Analysis, Particle Tracing, Neutron Physics, Computational Fluid Dynamics etc. In fact, Anupam-series of parallel computers have become the main workhorse for the computational work of the scientists and engineers of BARC. In addition to this, thirty-seven supercomputers of

ANUPAM series have been installed at leading R&D and educational institutions in the country including the National Center for Medium Weather Forecasting, New Delhi (currently operating from Noida, UP) and the Aeronautics Development Authority, Bangalore. The R&D work on ANUPAM has found its way into many prestigious publications. Scientists and Engineers of BARC and other institutes who have used ANUPAM for their research work, have published a number of articles in prestigious journals. Fig. 5 depicts a set of applications developed using Anupam.

Acknowledgements

One of the important tasks in commissioning a large

parallel computer is the preparation, planning, routing and deployment of a very large number of cables (which easily run into thousands) of various types in a confined space. All these cables were prepared, tested and deployed by our colleagues Mr. Kishor Koli, Mr. Samir Adhikari, Mr. Suresh Vasa and Mr. Manish Duble under strict time schedules. Their efforts deserve special mention. It is our pleasure to acknowledge the unstinting support lent by the Technical Services Division, BARC in providing specialized earthing and meeting our power and air conditioning requirements at short notice.

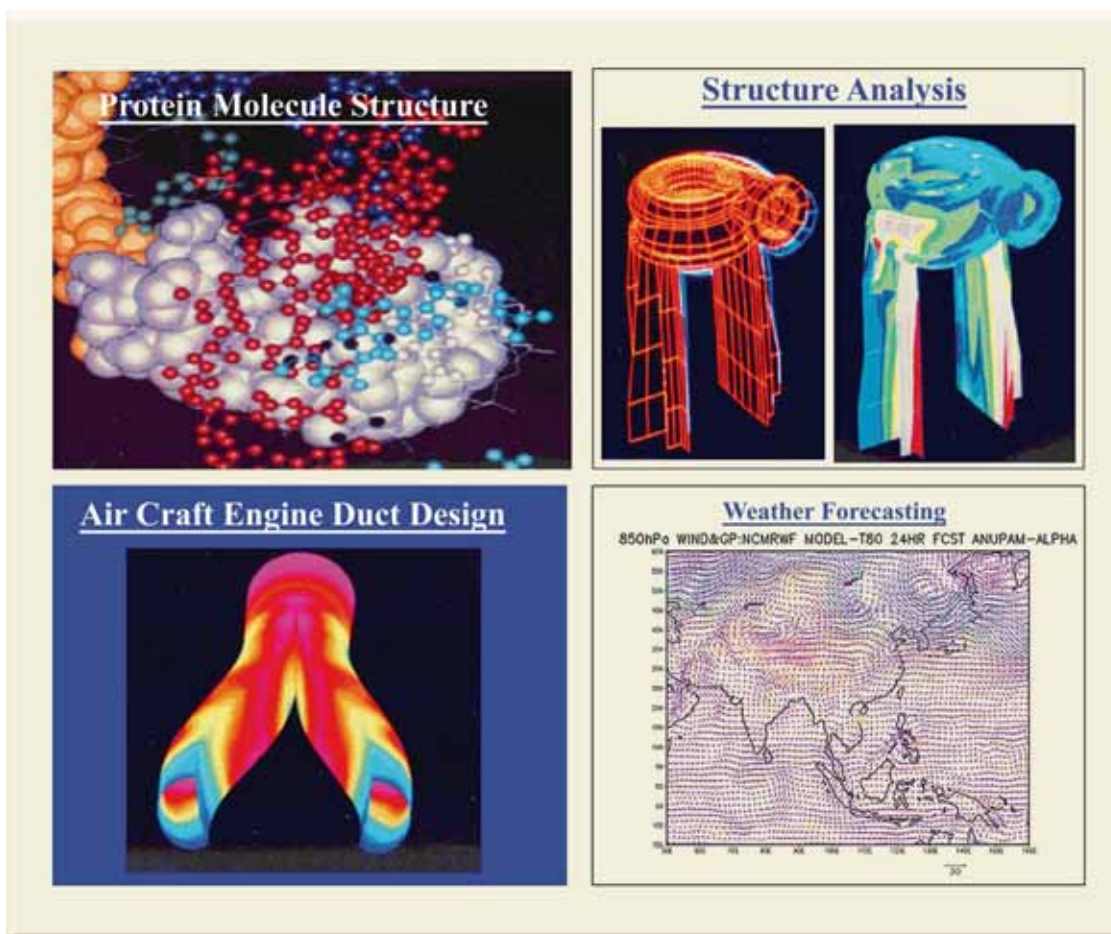


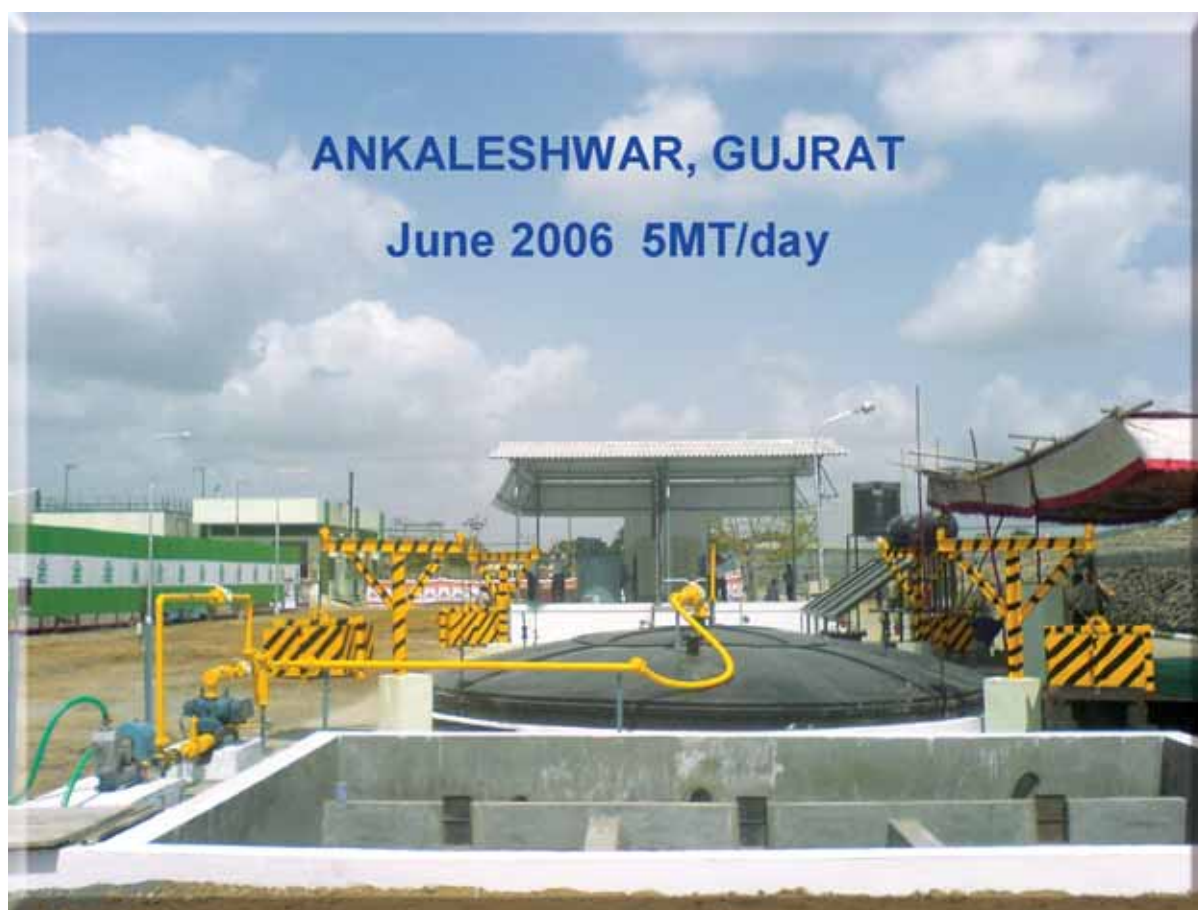
Fig. 5: Representative applications developed using Anupam

NISARGARUNA : HEALTH AND WEALTH OUT OF WASTE

NISARGARUNA - a biogas plant based on biodegradable waste, has been developed by BARC. The plant can process 1 to 5 tons of biodegradable waste per day in the form of kitchen waste, paper, grass, gobar, dry leaves, etc. to produce high quality weed-free manure and biogas. The manure obtained from such waste has high Nitrogen content and acts as an excellent soil conditioner. This plant could be set up for an eco-friendly disposal of wet-waste generated in kitchens /canteens of hospitals /

hostels / factories / residential complexes /vegetable markets / horse stables / poultry farms / cowsheds. It further reduces health hazards due to dump sites.

The waste in NISARGARUNA gets biodegraded by two processes viz. aerobic and anaerobic in a cascaded manner. In the first aerobic phase, it is largely converted into fumaric, acetic, butyric and other organic acids with the help of thermophilic bacteria. In the second anaerobic phase, this acidic waste gets further



degraded with the help of methanogenic bacteria to generate high purity methane and high quality manure, leaving no effluent whatsoever.

The technology has been transferred to different parties since 2003. It was also provided to Municipal Corporations through Memoranda of Understanding as well as to Non Governmental Organizations through Advanced Knowledge & RUrAl Technology Implementation (AKRUTI) programme as part of the DAE-Societal Initiative. Sixteen Nisargaruna plants of different capacities have already been commissioned, whereas 11 plants are under construction. Plants that are already functional include – one at Ankleshwar, Bharuch (chemical/industrial zone), at the hill station Matheran (for hotel waste and horse dung), at Orissa Power plant, at Deonar abattoir (for animal waste), at

Hiranandani Gardens, Powai (housing society) and those at Chandrapur and Nanded initiated by Municipal Corporations/Nagarpalikas.

The Nisargaruna technology was transferred to the 50th party, M/s Phoenix Poultry, Jabalpur (MP) on 5th November 2007. Agreement for transfer of technology was signed by the Director, BARC on behalf of BARC whereas Dr. G. G. Barley represented Phoenix Poultry, Jabalpur (MP).

Nisargaruna is a pioneering technology for urban and rural waste management. It offers an excellent alternative for decentralized processing of solid biodegradable waste.



On the occasion of the technology transfer agreement signing ceremony seen from left to right, Mr. A. M. Patankar, Head, TT&CD, Dr. K. B. Sainis, Dir, BMG, Dr. R. B. Grover, Dir, KMG, Dr. S. Banerjee, Dir, BARC, Dr. N. Khalap, TT&CD, Dr. G. G. Barley, DGM, M/s Phoenix Poultry, Jabalpur, Dr. S. F. D'Souza, AD, BMG and Head, NA&BTD, Dr. S. P. Kale, Head, PP&SS, NA&BTD and Dr. S. Saha, Head, TTS, TT&CD.

XVII TRAINING WORKSHOP ON RADIATION EMERGENCY PREPAREDNESS FOR MEDICAL OFFICERS : A REPORT

The XVII Training Workshop on Planning, Preparedness and Response to Radiation Emergencies for Medical Officers, was held under the aegis of Local Working Committee for Radiation Emergency Medical Response (REMR) of BARC, at Niyamak Bhavan, AERB from 9th Oct. – 12th Oct. 2007 and was inaugurated by Dr. K.B. Sainis, Director, Bio-Medical Group, BARC.

Dr. P.R. Bongirwar, Medical Officer-in-Charge of Trombay Dispensary and Chief coordinator of the workshop, welcomed the distinguished invitees, guests and delegates and briefly apprised them about the genesis of the training course. He said that during the course of the training workshop, all medical aspects and other relevant aspects of radiation injuries/emergencies would be comprehensively covered by various faculty members from BARC, DAE & AERB. The total number of delegates registered for the workshop were 49 and included multi-disciplinary specialists from Mumbai's four major teaching hospitals, doctors from Armed Forces Medical Units and Medical Officers from different constituent units of DAE.

Dr. V. Karira, Head, Medical Division and Chairman of the Local Working Committee of Radiation Emergency Medical Response (REMR) greeted the delegates and said in his introductory address that DAE has been identified as the nodal agency by the Govt. of India for advice on management of nuclear/radiological emergencies, occurring in the public domain. He further added that this training workshop which was training of trainers is being conducted with the objective that Medical Officers who would be trained in this workshop, in turn would train other medical and

para-medical personnel, at their respective work places. He further said that the expansion of nuclear power programme in the future and increasing use of radiation in various fields, had further increased the necessity for doctors, to be aware about management of radiation injuries, should they ever occur. He added that this course was particularly important in view of the fact that the present medical curriculum does not cover various aspects of diagnosis and management of radiation injuries and hence the vital need for conducting this workshop to bring awareness among the medical fraternity.

Dr. K.B. Sainis, Director, Bio-Medical Grp. in his inaugural address said that India is one of the few countries in the world which has mastered both the front- end as well as the back-end nuclear fuel cycle technology and is presently pursuing a three-stage nuclear power programme. He also said that this programme would undergo further expansion in the years to come. According to him, this training of trainers workshop would have a multiplier effect and this was particularly important because of rapid expansion of use of radiation technology in diverse fields such as Medicine, Agriculture, industry and in research. He then added that undue fear among the public regarding radiation, needed to be allayed as many health effects occur at high dosages and were dose-dependent. He emphasized the fact that the AERB was a national regulatory agency, which follows internationally prescribed limits, for radiation protection and ensures strict compliance in maintenance of safety.

He gave a brief overview of biological effects of ionizing radiation and said that no hereditary effects

had been observed, in the children of atomic bomb survivors of Hiroshima and Nagasaki. He outlined the role of UNSCEAR in analyzing data related to human radiation exposure and drawing conclusions about the radiation risk. He also spoke on the role of therapies like bone marrow transplant and the use of stem cells in the treatment of radiation injuries.

The training workshop spanning a period of four days, comprehensively covered all topics pertaining to radiation injuries/emergencies including assessment of psychological impact of radiation accidents and an overview of overall preparedness in dealing with management of radiation emergencies. It also included visit of delegates to BARC facilities viz. Emergency Response Centre, Personnel Decontamination Centre and Dhruva reactor and a one day visit was also arranged to the Radiation Medicine Centre and the Tata Memorial Hospital.

Dr. K.B. Sainis presided over the valedictory function which was held on October 12, 2007. Dr. H. M. Haldavnekar welcomed the chief guest and invitees. Dr. P.R. Bongirwar gave a brief summary of the training workshop which included written feedback from the participant delegates. In his valedictory address Dr. Sainis referred to a few radiation accidents and said that this was the 50th year of the Windscale accident at Cumbria in UK (Oct. 1957). He also drew attention of the delegates to the potentiality of a scenario, in which there could be malevolent use of radioactive sources in the public domain. He emphasized the importance of this training workshop as one of the crucial requirements as envisaged by the recently established National Disaster Management Authority (NDMA). He later distributed certificates of participation to the attending delegates. Dr. (Mrs.) A.A. Godse proposed a vote of thanks on behalf of the Local Working Committee. REMR, BARC.



At the valedictory function : left to right Dr. P.R. Bongirwar, Medical Officer-in-charge, Trombay Dispensary, Dr. V. Karira, Head, MD, Dr. K.B. Sainis, Director, BMG and Dr. K. Muralidhar, Secretary, AEC/CAC & Head, MSG

BARC SIGNS MoU WITH NPCIL TO SET UP INTEGRATED TEST FACILITY AT R&D CENTRE, TARAPUR

As part of the continuing R&D initiative towards the development of technology, relevant for the Indian nuclear power programme, a new infrastructure named "Integrated Test Facilities, Tarapur (ITFT)" was proposed to be created at the R&D Centre, Tarapur, jointly by BARC and NPCIL. The ITFT will accommodate experimental facilities required by NPCIL and BARC. To facilitate this, an MoU was signed by the Director, BARC and CMD, NPCIL on Aug. 18, 2007 in the presence of Chairman, AEC and other senior members of the DAE community.

BARC test facilities will consist of the AHWR Thermal-hydraulic Test Facility (ATTF) and the Fuelling Machine Test Facility (FMTF). ATTF will aim at full-scale qualification and generation of database for Advanced Heavy Water Reactor (AHWR), thermal hydraulics related to Main Heat Transport System and associated sub-systems, for ascertaining the available margins on design, with respect to Critical Heat Flux (CHF) and Stability. This information will help in enhancing the power obtainable from AHWR. FMTF will be used for the performance evaluation of a prototype fuelling machine with simulated

coolant channels. The NPCIL Thermal-hydraulic Test Facility (NTTF) and the Reactivity Devices Test Facility (RDTF) are the two facilities to be created by NPCIL as part of ITFT. The NTTF Facility is aimed at enhancing the understanding of various thermal-hydraulic phenomena for safe and reliable operation of PHWRs, especially those related to the ensuing 700 MWe reactors and beyond, which envisage partial boiling of primary coolant in fuel channels. In view of many common requirements such as large power source, supporting infrastructure, skilled and trained manpower this mutual sharing of resources would provide operational and economic benefits to both the organizations.



Dr. S. Banerjee, Director, BARC and Mr. S.K. Jain, CMD, NPCIL exchanging copies of signed MoU in the presence of Dr. Anil Kakodkar, Chairman, AEC. Also present are (from left to right) Mr. D.K. Sisodia, CS, R&D Centre, NPCIL, Mr. H.S. Bhambra, Associate Director (R&D-NS), NPCIL, Mr. Umesh Chandra, Sr. Ex. Director (R&D and KM), NPCIL, Mr. R.K. Sinha, Director, RD&DG and DM&AG, BARC, Dr. P.K. Vijayan, Head Thermal Hydraulic Section, RED, BARC and Mr. D. Saha, Head, RED, BARC.

TRAINING PROGRAMME ON NUCLEAR AND OTHER ADVANCED ANALYTICAL TECHNIQUES IN FORENSIC SCIENCE: A REPORT

A three day training programme "Nuclear and other advanced Analytical Techniques in Forensic Science" was organized by the NAA Unit of CFSL, Hyderabad, Analytical Chemistry Division (ACD) at BARC, Mumbai from December 5-7, 2007. The course was designed with the objective to widen awareness and to expose forensic scientists/document examiners to advances in analytical techniques. Various aspects of trace forensic analysis underlining the need for proper samples and sampling with quality assurance of data were highlighted by speakers in their relevant fields of expertise. Hands - on practicals on NAA and focus lectures on Nanotechnology and Isotope applications were also arranged. The course covered lectures and exposure to equipment facilities at the ACD, BARC, emphasizing the role of different nuclear and non-nuclear advanced analytical techniques in the forensic science context. Participants were also taken for a visit to 'APSARA' nuclear research reactor of BARC.

The programme was inaugurated by Dr. T. Mukherjee, Director, Chemistry Group, BARC, on December 5, 2007 in the 'C' Block Lecture Hall. Modular Laboratories, BARC. Delivering the inaugural address, Dr. Mukherjee stressed the potentiality of nuclear and other technologies, in helping solve crime cases. He also emphasized the need for updating knowledge and information in the pursuit of truth. He mentioned that there is a constant increase in organized crimes in the country. In the present day scenario, forensic scientists have to be alert and well equipped, to take up the challenges in forensic science. Dr. Mukherjee was emphatic in expressing the support and facilities received from BARC, to the unique forensic work programme which is an on-going national facility at ACD, BARC. Compiled lecture notes etc. in the form

of books were released by the Director, Chemistry Group, BARC.

Dr. S.K. Shukla, Director, CFSL, Hyderabad, formally welcomed the participants who had come from different places to attend the course. He reiterated the importance of NAA Unit functioning at BARC, Mumbai which is a unique work programme, being one of its kind not only in the country but also in the world. He also mentioned about the continued functioning of the Unit, for the last more than three decades. He stressed the significance of forensic science and value of expert opinion in the criminal justice system. Dr. Shukla specially thanked BARC/DAE functionaries for co-operation, support and the facilities provided to the NAA Unit personnel stationed at ACD, BARC, Mumbai. He also thanked DFS(MHA), New Delhi for administrative and financial support.

Dr. N. Chattopadhyay, Deputy Director, NAA Unit of CFSL, Hyderabad (at ACD, BARC) who was the Course Director, briefed about the design of the present training course and mentioned about the background of organizing such a type of meet. He outlined the topics of the lectures and their purpose. Dr. Chattopadhyay thanked the Director, CFSL, Hyderabad and DFS authorities for financial and administrative support.

Dr. G. Venkateswaran, Head, ACD, BARC, Mumbai, gave an introductory address on the collaborative work programme of the forensic Unit situated at ACD, BARC. He also gave a brief account about the types of analysis done by the NAA Unit scientists in dealing with cases. He pointed out in brief, the specific necessity of high resolution gamma spectrometry

equipment in carrying out neutron activation analysis of samples, to achieve simultaneous multi-element determination capability.

Dr. (Mrs.) R. Krishnamurthy, Director, Forensic Science Laboratory, Mumbai in her brief address, mentioned about the latest techniques in forensic analysis. She informed the gathering about the modernization of the state FSL in Mumbai, with the availability of unique facilities. She also cited the potential role of latest tools like brain finger printing, narco analysis, DNA test facility etc. with implications to help crime investigation. Dr. (Mrs.) Krishnamurthy advised the participants to take advantage of the opportunity of exposure to the multi-disciplinary facilities, existing in BARC, which is a premier research organization in the country.

Dr. A.K. Basu, Asstt. Director, NAA Unit of CFSL, Hyderabad proposed the vote of thanks. Dr. A.B.R. Tripathi and Mr. C.A. Bhadkambekar of the NAA Unit co-ordinated the inaugural function. Mr. S.P. More of the NAA Unit, rendered invaluable services in arranging the training programme.

Dr. M.S. Rao, Director-cum-Chief Forensic Scientist, DFS, MHA, Govt. of India, New Delhi through a message, conveyed that employing sophisticated analytical chemistry techniques, with both nuclear and non-nuclear approaches, helps in crime detection/prevention. He indicated that forensic case exhibits received in the laboratories were not only varied in nature but also different from normal laboratory analysis. The examination of forensic exhibit samples requires the application of appropriate technical skills by forensic experts. He hoped that selected topics and aspects of different analytical techniques would be of immense benefit to the forensic scientists. Dr. Rao extended his good wishes for successful deliberation with fruitful interaction between the participants and the organizers. He conveyed his thanks to all

functionaries of BARC (DAE) for the support, facilities and extending all possible help to the officials of NAA Unit in organizing this programme. Dr. S. K. Shukla, Director, CFSL, Hyderabad rendered full administrative and financial support enabling all arrangements to be made in a smooth and efficient manner.

A total of 25 participants from different FSL(s), CFSL(s), GEQD and BARC attended the course. A special lecture on "Curbing Narco – Terrorism" was delivered by Dr. S. K. Shukla, Director, CFSL, Hyderabad in the "C" Block Lecture Hall after the inaugural function on 5th Dec. 2007. Guest faculty members / resource personnel delivered their respective lectures during technical sessions. Topics on a wide range of advanced analytical techniques like NAA, ICPAES, ICP-MS, AAS, EDXRF, Thermal analysis, Chromatography etc. and uncertainties of measurements in chemical analysis, were highlighted in the presentations.

On the final day response sheets as feedback completed by each participant were collected for future reference. This was followed by a group discussion. Dr. N. Chattopadhyay initiated the informal discussion and mutual interaction. Dr. G. Venkateswaran, Head, ACD, BARC subsequently chaired the session. He reviewed each feedback response sheet submitted by the participants. He shared his valuable views with all present. Dr. Chattopadhyay clarified certain points regarding the issue on enhancing the duration of the course. Finally in the valedictory function, Dr. Venkateswaran, Head, ACD, gave an overview on summary on feedback. Dr. N. Chattopadhyay, Course Director expressed his observations. Some of the participants expressed their views on the usefulness of the programme.

Dr. T. Mukherjee, Director, Chemistry Group, BARC in his valedictory remarks mentioned that interactive deliberations and first hand exposure will be fruitful for the participants in enriching their knowledge. He

was hopeful that this would generate fresh momentum to catalyze reading and updating knowledge on the latest trends in crime investigation. The Chief guest of the valedictory function Mr. Niket Kaushik, IPS, Dy. Commissioner of Police, Zone -6, Mumbai presented the certificates to each participant. In his address, Mr. Kaushik congratulated the organizers in arranging such a wonderful course involving expert

scientists of BARC. He desired more effective interactions among police and forensic scientists with the hope that police personnel would be given opportunities to interact with scientists, to derive benefit from technical procedure of forensic analysis. Dr. A. B. R. Tripathi was the master of the ceremony of the valedictory function. He also proposed the vote of thanks.



Dr. T. Mukherjee, Director, Chemistry Group, BARC, releasing compiled lecture notes in the form of books during the inaugural function. Seen in the photograph from left to right are : Dr. N. Chattopadhyay, Deputy Director, NAA Unit of CFSL (H), ACD, BARC, Dr. G. Venkateswaran, Head, Analytical Chemistry Division, BARC, Dr. S.K. Shukla, Director, Central Forensic Science Laboratory, Hyderabad, Dr. T. Mukherjee, Director, Chemistry Group, BARC, Dr. (Mrs) R. Krishnamurthy, Director, Forensic Science Laboratory, Maharashtra State and Dr. A.K. Basu, Assistant Director, NAA Unit of CFSL (H), ACD BARC.

A BRIEF REPORT OF THE “FIRST SUPERVISORY TRAINING PROGRAMME ON SPENT FUEL REPROCESSING”

The First Supervisory Training Programme on Spent Fuel Reprocessing was conducted by the Training & Qualification Cell, NRG, at the A-block Auditorium, Mod Lab, Trombay, BARC during 20th-31st Aug. 2007. The training programme covered various aspects of spent fuel and spent fuel reprocessing philosophy, generation of spent fuel, transportation and different steps in reprocessing. The programme also covered important aspects of radiation protection and various aspects of safety and instrumentation.

This two-week training programme was designed for personnel who are working in various plants in NRG and have not received any formal training. A total of about 50 participants attended this course. They were given this training for complete acquaintance with various aspects of spent fuel reprocessing. There were junior engineers, supervisors and senior technicians working in reprocessing and waste management plants/facilities and in projects from Trombay, Tarapur and Kalpakkam. The training



At the inauguration from left to right : Mr. R.G. Yeotikar, Officer-in-charge, Training Programme, Mr. P.B.S. Sengar, Head, HCD&ES, Mr. Kanwar Raj, Head, WMD, Mr. S. Basu, Associate Director, Projects, NRG, Mr. S.D. Misra, Director, NRG and Mr. P.K. Dey, Head, FRD

programme was carried out by way of classroom lectures, plant visits and demonstrations. Faculty members who were specialists in their fields delivered the lectures.

The inauguration of this training programme was done on 20th August 2007 and was graced by Mr. S.D. Misra, Director, NRG; Mr. S. Basu, Associate Director, Projects, NRG; Mr. P.K. Dey, Head, Fuel Reprocessing Division, Mr. Kanwar Raj, Head, Waste Management Division; Mr. Shyamal Das, CDE Process, RP, NRG, Mr. P.B.S. Sengar, Head, HCD&ES, Mr. S. K. Munshi, CS, RF, PP and many senior officials of NRG. Mr. R.G. Yeotikar, Officer-in charge, Training,

NRG and organizer of this programme welcomed the trainees and dignitaries. He briefed the audience about the objectives of the training programme and explained about the importance of the selected subjects. Mr. S.D. Misra, Mr. S. Basu, Mr. P.K. Dey and other dignitaries appreciated the effort and emphasized how this training was essential and useful for updating knowledge in spent fuel reprocessing. The certification ceremony and valedictory function was graced by Mr. P.K. Dey, Head, Fuel Reprocessing Division and many senior officials from NRG. Feedback about the subjects selected for training, plant visits and overall training programme was taken from all the trainees for improvement of future training programmes.



Seen among the audience in the front row from right to left : Mr. S. Das, CDE Process, RP, NRG, Mr. S.K. Munshi, CS, RF, PP and Mr. B.B. Verma, WMD

DAE SYMPOSIUM ON NUCLEAR PHYSICS 2007: A REPORT

The 52nd DAE Symposium on Nuclear Physics was held at Sambalpur University, Burla, Orissa, during December 11-15, 2007. This annual national event, which is organized by the Nuclear Physics Division, BARC, is the most awaited forum for the whole Nuclear Physics community of India, where new results and ideas on various frontier areas of Nuclear Physics are presented and exchanged among the participants. This year, there was an overwhelming response from the participants from different parts of the country. A record number of 233 contributory papers and

15 theses on different areas of Nuclear Physics were presented at the symposium. In addition to this, there were 26 invited talks by reputed speakers from both India and abroad. The topics covered were: a) Nuclear structure b) Low and medium energy nuclear reactions, c) Physics with radioactive ion beam, d) Intermediate energy nuclear physics, e) Physics of hadrons and QCD, f) Relativistic nuclear collisions and QGP, g) Nuclear astrophysics and nuclear matter, and h) Accelerators and instrumentation for Nuclear Physics.



At the Inaugural function from L to R are: Dr. Aswini Kumar Rath (Local Convener), Dr. A.K. Mohanty (Convener), Dr. B.C. Sinha (Director, VECC and SINP), Dr. U.C. Biswal (Vice Chancellor, Sambalpur University), Prof. J. Mohapatra (Chairman, PG Council & Head, Phys. Deptt., SU), Dr. R.K. Choudhury (Symposium Chairman and Head, Nuclear Physics Division), Dr. G.N. Dash (Co-ordinator, Dept. of Phys., SU)

The symposium was formally inaugurated by Prof. Bikash Sinha, Director, Variable Energy Cyclotron Centre and Saha Institute of Nuclear Physics, Kolkata, who is an eminent nuclear physicist and a key policy maker for many scientific activities in India. Prof. Sinha also delivered the keynote lecture, where he emphasized the role of Nuclear Physics starting from the point of creation of the Universe to the formation of stars and elemental synthesis. He stressed two very important aspects of scientific development in any country namely

1. Universal collaboration spanning the Globe as one scientific family
2. The emergence of path breaking technological advancement as a byproduct/ spin-off of the pursuit for fundamental science.

Numerous examples were given by him including sophisticated vacuum technology, civil engineering tools, parallel high speed grid computing etc. which

were necessarily developed, for achieving the experimental goal of particle-particle interaction, at the fundamental level. He emphasized on striving for excellence in all fields of scientific activities (both experiment and theory) which was automatically warranted because of global participation and competition. He suggested that the national policy framers should now rethink on a major revision of the scientific policy for reversal of trend in favor of basic sciences, in order to make a career in basic sciences more attractive.

Technical programme

The technical presentations were made on the ongoing research activities in India and through international collaborations and covered major areas of both experimental and theoretical Nuclear Physics. During the five-day deliberations, the following number of research papers in different categories were presented.



Prof. Bikash Sinha delivering the key note address at the inaugural function

Category	Sub-areas of nuclear physics	No of papers presented (Contributory+Invited)=Total
A	Nuclear Structure	(57+6)=63
B	Low and Medium Energy Nuclear Reaction	(73+4)=77
C	Physics with Radioactive Ion Beam	(6+3)=09
D	Intermediate Energy Nuclear Physics	(23+2)=25
E	Physics of Hadrons and QCD	(6+1)=07
F	Relativistic Nuclear Collisions and QGP	(20+0)=20
G	Nuclear Astrophysics and Nuclear Matter	(12+0)=12
H	Accelerators and Instrumentation for Nuclear Physics	(38+8)=46

Prof. Phil Walker of the University of Surrey, UK, talked about high-K isomers and touched on the fundamental issue of these nuclear states. He mentioned that more research work was necessary to release the energy from the isomer to make nuclear batteries. Prof. A. Covello, from INFN, Italy, reported a study of exotic nuclei around doubly magic nuclei ^{132}Sn by realistic shell model calculation. He emphasized that there was no need to invoke shell-structure modifications, to explain the presently available data on neutron-rich nuclei beyond ^{132}Sn . In the talk by Dr. S. Santra, study of hadronic weak interaction and measurement of weak coupling constant using cold neutrons from spallation neutron source at LANL and ORNL, was shown to be a good example of a fundamental nuclear physics research. A summary of other invited talks is given below.

A short review on "Recent advances in measurements of the nuclear level density" was presented. Significant variations observed over and above the expected shell corrections were discussed in the context of the emerging trends in microscopic calculations of the

nuclear level density. The response of the nucleus to the rotational stress (due to high angular momentum) gives rise to a wide variety nuclear structure phenomena. A talk on the evolution of nuclear structure with angular momentum was presented. There was a talk on the radioactive ion beam (RIB) facility at TRIUMF-ISAC, which provides a wide range of radioactive species at different energy ranges. With the high efficiency 8p spectrometer, nuclei with beam intensity as low as 1s^{-1} can be studied. The physics being addressed by this spectrometer varies from exploring the shell structure of nuclei far away from β -stability to the collective excitation, isomeric states in nuclei and β -delayed particle-g spectroscopy. One of the main physics programs explores the area of super-allowed Fermi- β decay for CKM matrix unitarity test. Another interesting talk using RIBs was to find the neutron correlation in the borromean nucleus ^6He (seen as $\alpha+2\text{n}$). Measurement of dipole strength distribution in neutron-rich Ni, Sn and other nearby nuclei is another study involving RIBs. Indirect measurement of capture cross sections relevant to astrophysical phenomena were also discussed.

There was a presentation on the nuclear symmetry energy in the framework of Brueckner-Hartree-Fock (BHF) formalism, that leads to determination of the neutron skin thickness of ^{208}Pb to be 0.2 fm and the radius of 1.4 solar mass neutron stars as ~ 21.3 km. There was a review talk on “Quark-Gluon Plasma-Present and Future”, covering the frontier area in the field of relativistic heavy ion collisions. The possibility of probing the QCD critical point with an energy scan at RHIC and FAIR facilities was also discussed.

The results from the ongoing international programs associated with STAR, PHENIX, ALICE, CMS, FAIR etc. were presented at the symposium. Many groups from BARC, VECC, Bhubaneswar, Jammu, Jaipur, Delhi, Aligarh etc. are participating in the above programmes.

In the nuclear instrumentation sector, there were talks on a) Advances in gas avalanche detectors and their applications, b) Magnetic separator for light RIB production, c) INGA and NAND instrumentation, d) High energy gamma ray spectrometer and e) A data acquisition system for pelletron-LINAC experiments. The activities and status of various accelerator facilities in the country were updated. The superconducting cyclotron, a major accelerator facility at VECC is expected to be commissioned in 2008. The work on a RIB facility using the 88" variable energy cyclotron at VECC is also in progress. The upgradation of the present pelletron accelerators of both IUAC and BARC/TIFR with the addition of LINAC to boost the energy of the ion beams have made significant progress.

Orientation program

A one day pre-symposium orientation program on “Introduction to Hadron and Neutrino Physics” was arranged on 10th December, the preceding day of the main symposium. This was aimed at the students and young researchers to orient themselves through special lectures and intensive interaction with scientists who are experts in the field.

Evening Lectures

There were two popular evening (semi technical) lectures by Prof. V. S. Ramamurthy and Mr. Abasar Beuria. Prof. Ramamurthy (former secretary, DST, Govt. of India, presently DAE Homi Bhabha chair Professor, IUAC-Inter University Accelerator Centre, New Delhi) stressed the fact that **researchers should look for areas where observations and/or theoretical results are apparently anomalous**. He emphasized that giving up such anomalous results which do not confirm to the prevalent scientific wisdom, may actually hide more profound, novel aspects and therefore should be pursued at any cost. To substantiate this point of view, he cited several path-breaking discoveries which were the results of **chasing** such “anomalous findings”.

Mr. Beuria, IFS, in his evening talk on “Contemporary world and cultural crisis” highlighted the onslaught of the currently witnessed phenomenon of globalized market economy on the cultural values, ethnicity and the identity issue of the various communities. He advised the intellectual community to imbibe/ absorb the essence of the brighter and progressive aspects of the different global communities while retaining their own identity, cultural heritage and moral values.

Awards

Following the tradition of the symposium, the best presentations on a) thesis and b) poster were awarded. As a first step, a panel of judges selected the three best theses for oral presentation. One of the three best theses was then selected for the “C. V. K. Baba Best Thesis Award”, which was earlier known as “The IPA best thesis award”. In the poster category, there were three more awards. A different set of judges chose the three best posters out of the 173 presentations for the “Best poster award”.

Concluding remarks

Dr. R.K. Choudhury, Chairman, National Organizing Committee, SNP-07, and Head, Nuclear Physics Division, BARC, presided over the award ceremony meeting and gave the concluding remarks. He urged the various experimental groups to come forward with proposals and planning for the effective utilization of the upcoming new (e.g., K500 super-conducting cyclotron) facilities at Kolkata and upgraded accelerator facilities (e.g., LINAC) at Delhi and Mumbai. He pointed out that a lot of scope is available with the upcoming international facilities such as FAIR facility at GSI, Germany and LHC at CERN, where India is expected to take many major responsibilities in various fields.

Dr. Ajit Kumar Mohanty, Convener of the symposium thanked the host institution for excellent arrangements for the symposium which would remain as a benchmark in the organization of the DAE Symposium on Nuclear Physics. Dr. Aswini Kumar Rath, Local convener of the symposium thanked DAE, BRNS and the staff, volunteers of the Dept. of Physics, Sambalpur University for their kind support and untiring help. The symposium ended with the invocation of the Vedic Shanti Mantra by Diptimaya Dash.

ANNOUNCEMENT Forthcoming Symposium

National Symposium on Environment NSE-16

The National Symposium on Environment, the sixteenth in the series, is being held at Guru Jambheshwar University of Science and Technology, Hisar from July 16-18, 2008. The symposium is sponsored by the BRNS, DAE and is jointly organized by the Dept. of Environmental Science & Engg., Guru Jambheshwar Univ. of Science & Technology, Hisar and the Health, Safety and Environment Group, BARC.

Papers on the following topics : Groundwater for Sustainable Development : Problems, Perspectives and Challenges; air pollution monitoring and abatement; solid, biomedical and hazardous waste management; monitoring and modelling of pollutants and their transport; environmental radioactivity; climate change; biodiversity conservation; environmental awareness, legislation and regulations are invited for presentation at the symposium. The soft copy of the paper should be sent to Mr. V.D. Puranik, Chairman, Technical Programme Committee (NSE-16) by e-mail at puranik@barc.gov.in.

Best paper awards have also been instituted at the symposium.

Important Dates

Acceptance of paper	: April 15, 2008
Submission of registration forms	: April 30, 2008
Payment of registration/ accommodation fee	: April 30, 2008

For further details one may contact

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BARC TRAINING SCHOOL : FIRST BATCH ALUMNI MEET

A meeting of the first batch of Alumni of the DAE Training School, now renamed the BARC Training School, was held from December 27-29, 2007, at the Multipurpose Hall of the Training School hostel, BARC. Around 50 trainees of the first batch, who had joined the training programme in August 1957, attended the meet. Dr. H.J. Bhabha initiated the DAE Training programme to turn out well trained scientific and technical manpower, required to start India's fledgling nuclear power programme. True to its mandate, the BARC Training School perseveres even today.

The enthusiasm and the drive of the first batch trainees (many of whom retired as pioneers of India's nuclear

power programme) can be evinced from the fact, that they came together, to form an Association of BARC First Batch Trainees, with Mr. U.C. Mishra as their President, Mr. B.A. Dasannacharya as Secretary, Mr. P.P.V.J. Nambiar as Joint Secretary and Mr. A.J. Singh as Treasurer. They came from USA, Canada, Hyderabad, Chennai, Kochi, Thiruvananthapuram and Mumbai to visit BARC, their parent organization.

Dr. K.K. Damodaran, 86, who was in charge of the training school in 1957, commenced the meet on the 27th. After the registration, there was a presentation by Mr. U.C. Mishra. He detailed the formation of the Association and the decision of



At the inaugural meet from L to R : Mr. V.B. Kartha, Former, Head, Spectroscopy, Divn., Mr. U.C. Mishra, President, BARC First Batch Trainees Association, Dr. R.R. Puri, Head, HRDD and Dr. K.K. Damodaran, former in-charge Training school

it's members to visit BARC and Tarapur. Accordingly, Dr. S. Banerjee, Director BARC and Mr. S.K. Jain, CMD, NPCIL were contacted and they graciously agreed to hold the meet and organize the visit. Mr. Mishra's presentation was followed by Dr. Damodaran's reminiscences, who nurtured the training school during it's first 25 years. Dr. R.R. Puri, Head, HRDD gave details of the newly formed deemed university, HBNI.

On the 28th of December, the invitees gathered at BARC and were met personally by Dr. Banerjee, Director, BARC, who gave them a briefing about the current activities in DAE in general and BARC in

particular. Later, the group had an informal discussion with members of the Trombay Council. The group visited Dhruva, Computer Centre, Waste Immobilization Plant and FIPLY. All the invitees were presented with mementoes.

On the 29th of December, the group visited TAPS 3&4. Mr. O.P. Goyal, Station Director, briefed the members and explained about the special features of the plants. They also visited the control Room, Turbine Room and the Reactor Vault at TAPS 3&4.

The visit concluded with mementoes and a vote of thanks on behalf of all the members.



Group photograph of the alumni of the first batch trainees and other invitees

REPORT OF THE 2ND RESEARCH CO-ORDINATION MEETING OF THE IAEA ON “NEUTRON-BASED TECHNIQUES FOR THE DETECTION OF ILLICIT MATERIALS AND EXPLOSIVES”

The illicit trafficking of explosives through conventional commercial networks (air, maritime and terrestrial) represents a real challenge to civil security. The inspection of containers is largely based on X-ray or gamma ray systems, but it provides limited information about contained objects such as their shape and density. It is not always possible to distinguish between materials that are harmless or harmful using X-rays alone and there is a need for additional information about the chemical composition of the suspect items, in order to detect illicit materials such as explosives, drugs or dirty (radioactive) bombs. Neutron interrogation, therefore, offers the possibility of

measuring the elemental density of most elements in materials. Neutrons, in particular fast neutrons, are well suited to explore large volume samples because of their high penetration range in bulk materials.

Exploring the methods and devices for practical application of neutron-based techniques for such applications, was the theme of a recently conducted second Research Co-ordination Meeting of the IAEA, on “Neutron-based Techniques for the Detection of Illicit materials and explosives,” held at Hotel Citizen, Juhu, Mumbai from 12 to 16th Nov. 2007. The meeting was hosted by BARC. Eighteen participants from



At the inauguration from left to right : Dr. Ms. Françoise Mulhauser, IAEA representative, Dr. S. Kailas, Associate Director, Physics Group, BARC and Dr. Amar Sinha, LNPS, BARC

different countries and some invited delegates from BARC attended this CRP meeting. The meeting was inaugurated by Dr. S. Kailas, Associate Director, Physics Group. Dr. Amar Sinha of LNPS, BARC was the local convener of this meeting and was ably assisted by his colleagues in organizing this meeting.

Technical Sessions

Dr. Ms. Francoise Mulhauser, IAEA representative reported on the activities of IAEA in the field of neutron-based techniques and also outlined the scope of the meeting.

There were six sessions each with several presentations on topics such as Neutron sources, Nanosecond neutron pulses, Neutron backscattering, Associated Particle Imaging, Neutron radiography, Systems, simulation and modelling.

Dr. A. Kuznetsov from the Radium Institute, Russia presented his work which was done in collaboration with five international organizations including NATO and an industry partner. He discussed the systems for detection of explosives and fissile materials based on Associated Particle Imaging (API) technique in which associated alpha particles in the binary reaction ${}^2\text{H} + {}^3\text{H}$ in coincidence with the emitted neutron are used, for tagging the emitted neutron, with respect to its time of emission and direction. Such a technique, allows the inspection of a chosen element of volume (voxel), out of a large investigated object such as a maritime container, using time-of-flight methodology for tagged neutrons. A brief introduction on a similar technique for explosive and fissile material detection in maritime cargo, based on EURITRAC project, which is under advanced stage of development and testing, by a Consortium of 16 European partners, was also presented.

Dr. Brian D. Sowerby from CSIRO, Australia, presented a new scanner used at Brisbane airport to inspect

containers for airfreight cargo. The concept is based on combined transmission radiography through the container, using fast neutrons produced with a D-T neutron source and gamma rays produced by a Co-60 source along with a novel detector design. The relative transmissions are sensitive to small differences in the compositions of organic materials. Prof. Leopoldo Soto, from Comisión Chilena de Energía Nuclear (CCHEN) spoken about his work on the development of portable neutron sources, based on pinch and plasma focus discharges. Work on design of several portable neutron devices based on plasma focus of (a) several hundred Joules (b) 30-100 Joules and (c) only about 0.1 Joule (the Nanofocus device), were presented by him, during the meeting. Dr. Leri Meskhi from Georgian Technical University presented his work on a portable neutron device, which indicates the presence of hidden organic materials such as illicit materials or explosives, within spaces just below the external cladding of cargo, containers or vehicles. The method is based on detecting the higher concentrations of thermalized neutrons, produced, when concentrations of organic materials are located nearby. Prof. Richard Lanza from MIT, USA made a presentation on a device, based on fast neutron resonance radiography, for the detection of explosives. Prof. Vladimir Gribkov from ITEP, Moscow, discussed a technique of explosive detection in cargo, using single intense neutron pulse 10-20 ns long, produced using a plasma focus device based on D-D reaction. Dr. Colin Murray Battle from New Zealand, presented the use of small, low cost portable neutron probes, to detect harmful materials, enhanced through comparative techniques such as detecting radiation at different viewing angles. Prof. Victor Bom from Netherlands, displayed the neutron backscatter technique, which has been configured into a light hand-held device, as well as a platform-mounted wide-area imaging system, that has undergone through advanced laboratory tests and is ready for field applications. Prof. Riad Mostafa Megahid from Egypt, presented the use of isotopic sources for explosive detection.

Mr. Roberto E. Mayer from Argentina, discussed about his work on pulsed electron Linac-based neutron generation and time-of-flight method for thermal and epithermal neutrons for explosive detection, whereas, Dr. Christopher Franklyn from NECSA, South Africa, showcased his work on Intense pulsed neutron generation, based on the principle of plasma immersion ion implantation technique, to detect illicit materials. Dr. Tsuyoshi Misawa from Japan presented his work on the development of compact, discharge-driven D-D fusion neutron source and its application for landmine detection. A report on simulation and modeling for optimization of associated particle based imaging devices and utilization of photoneutron

sources for inspection and status of experiments with neutron generators, was presented by Dr. Amar Sinha from BARC and Mr. Surendra Sharma, IPR, India.

It was recognized, that neutron-based technologies may not represent the first level inspection, but rather a second level target-specific system, which follows x-ray inspection. Detection of Special Nuclear Materials (SNM) remains a potential exception and neutrons would play a special role in such applications.

As part of this meeting, a visit to BARC was also organized.



A group photograph of the participants

New Publication

Nuclear Reactor safety

Eds.

S. Banerjee, BARC and

S.K. Gupta, AERB

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BRNS, Mumbai; 2007

Nuclear reactor safety is an intrinsic part of nuclear power generation. Several aspects of nuclear reactor safety such as regulatory, R&D, operation and power generation have to be taken into account, for various types of reactors: operational and those under construction.

The present volume is a compilation of research papers written by scientists and engineers working on nuclear reactor safety in India. It spans eight chapters and covers various safety aspects in the operation of PHWRs, Research reactors, AHWR and the Prototype Fast Breeder Reactor (PFBR). Leak-Before-Break, Design Basis Events, Loss-of-Coolant Accident, severe accidents and severe core damage have been elaborated in this compilation. In the case of PFBR, Safety issues such as Core Disruptive Accident (CDA) analysis, seismic analysis of NSS components, Core Monitoring Systems, Design Basis Events, Decay Heat Removal etc. have been discussed.

Students of Nuclear Engineering in India, would find the easy-to-understand writing style, very useful.

भा प अ केंद्र के वैज्ञानिकों को सम्मान BARC SCIENTISTS HONOURED

मार्च 25-30, 2007 के दौरान गोवा में आयोजित मॉस स्पेक्ट्रोमीट्री पर बारहवीं आइएसएमएस संगोष्ठी एवं कार्यशाला में ईंधन रसायनिकी प्रभाग के दो शोध-पत्रों को पुरस्कृत किया गया। श्रीमती डी. अलमेल्यू एवं एस. के. अग्रवाल द्वारा लिखित “²³⁸पीयू स्पाइक फॉर दि डिटरमिनेशन ऑफ कन्सन्ट्रेशन ऑफ पीयू बई आइसोटोप डाइल्यूशन टेक्नीक; फीजिबिलिटी एनालिसिस” नामक प्रथम शोध-पत्र को पोस्टर प्रजन्टेशन वर्ग का द्वितीय पुरस्कार प्राप्त हुआ। इसके साथ ही के. ससीभूषन, आर.गोविंदन, डी. अलमेल्यू, पी. एस. खोडाडे एवं डा.एस. के. अग्रवाल द्वारा लिखित दूसरे शोध-पत्र “साइमलटेनियस डिटरमिनेशन ऑफ यूरेनियम एन्ड प्लूटोनियम इन डिजॉल्वर सोल्यूशन इरेडियेटेड फ्युअल, यूजिंग आइडी-टीआइएमएस” को इन्वोवेटिव रिसर्च प्रजन्टेशन वर्ग का द्वितीय पुरस्कार प्राप्त हुआ।

Two papers from the Fuel Chemistry Divn., received prizes at the 12th ISMAS Symposium-cum-workshop on Mass spectrometry, held at Goa, during March 25-30, 2007. The first paper titled “²³⁸Pu Spike for the determination of concentration of Pu by isotope dilution technique; feasibility analysis” by Ms. D. Alamelu and Dr S.K. Aggarwal, received the second prize in the Poster presentation category. The second paper titled “Simultaneous Determination of uranium and plutonium in Dissolver solution irradiated fuel, using ID-TIMS” by K. Sasi Bhushan, R. Govindan, Ms. D. Alamelu, P.S. Khodade and S.K. Aggarwal also received the Second Prize in the Innovative Research Presentation category.



Dr. S.K. Aggarwal

डॉ.एस.के. अग्रवाल, वर्तमान में ईंधन रसायनिकी प्रभाग, भापअ केंद्र में अध्यक्ष हैं। उन्होंने वर्ष 1972 में गुरु नानक देव विश्वविद्यालय, अमृतसर से दो स्वर्ण पदकों के साथ बी.एससी (ऑनर्स) प्राप्त करके भापअ केंद्र के प्रशिक्षण विद्यालय के 16 वें बैच में शामिल हुये। वर्ष 1980 में उन्होंने मुंबई विश्वविद्यालय से अपनी पीएचडी

की। डॉ. अग्रवाल ने अनेक अंतरराष्ट्रीय एवं राष्ट्रीय सम्मेलनों तथा विविध अंतरराष्ट्रीय अंतरतुलनात्मक प्रयोगों में भाग लिया है। वे परमाणु मास स्पेक्ट्रोमेट्री एवं अल्फा स्पेक्ट्रोमेट्री के क्षेत्र के विशेषज्ञ हैं एवं अनेक मास स्पेक्ट्रोमिति तकनीकों में इनकी अभिरुचि है। विद्युतरसायनिकी एवं विलायक निष्कर्षण इनके अन्य अभिरुचि के क्षेत्रों में शामिल हैं। अंतरराष्ट्रीय मास स्पेक्ट्रोमेट्रिक सम्मेलनों की कार्यकारी समिति में वे भारत का प्रतिनिधित्व करते हैं। वे मुंबई विश्वविद्यालय एवं एच बी एन आई के मान्यताप्राप्त पीएचडी गाइड हैं।

Dr.S.K.Aggarwal, is currently, Head, Fuel Chemistry Division, BARC, Trombay. After B.Sc. (Hons.) from Guru Nanak Dev University, Amritsar, in 1972 with two Gold Medals, he joined the 16th Batch of BARC Training School and received the Homi Bhabha Award. He did his Ph.D. from Mumbai University in 1980. Dr. Aggarwal has participated in several international and national conferences and in different international intercomparison experiments. He is a specialist in the field of atomic mass spectrometry and alpha spectrometry and is interested in various mass spectrometric techniques. His other areas of interest include electrochemistry and solvent extraction. He represents India in the Executive Committee of International Mass Spectrometric Conferences. He is a recognized Ph.D. Guide of the Mumbai University and of HBNI.



D. Alamelu

सुश्री डी. अलमेलू ने अपनी एम.एससी उपाधि अन्नामलै विश्वविद्यालय से प्राप्त की। भापअ केंद्र के प्रशिक्षण विद्यालय के 38वें बैच से उपाधि प्राप्त करने के पश्चात वर्ष 1995 में उन्होंने ईंधन रसायनिकी प्रभाग के मास स्पेक्ट्रोमेट्री अनुभाग में कार्यग्रहण किया। तब से, वे सक्रिय रूप से स्वदेशी टाइम आफ फ्लाइट मास स्पेक्ट्रोमीटर के विकास से जुड़ी हैं। उनकी अन्य अभिरुचि के क्षेत्र में तापीय आयनीकरण मास स्पेक्ट्रोमेट्री एवं अल्फा स्पेक्ट्रोमेट्री शामिल हैं।

Ms.D.Alamelu, obtained her M.Sc. Degree in Physics from Annamalai University. After graduating from 38th Batch of Training School, BARC, she joined the Mass Spectrometry Section of the Fuel Chemistry Division in 1995. Since then, she has been actively involved in the indigenous development of Time of Flight Mass Spectrometer. Her other areas of interest include thermal ionization mass spectrometry and alpha spectrometry.



R. Govindan

श्री गोविंदन ने अन्नामलै विश्वविद्यालय से एम.एससी की डिग्री प्राप्त की। 14 वर्षों तक प्रगत ईंधन संविरचन सुविधा, भापअ केंद्र तारापुर में कार्य करने के पश्चात उन्होंने ईंधन रसायनिकी प्रभाग के मास स्पेक्ट्रोमेट्री अनुभाग में कार्यभार ग्रहण किया। आजकल वे परिशुद्ध आईसोटोप विश्लेषण तथा घटकों

के सान्द्रण निदर्शन हेतु इनार्गेनिक मास स्पेक्ट्रोमेट्री के क्षेत्र में कार्य कर रहे हैं जो कि नाभिकीय प्रौद्योगिकी के क्षेत्र में महत्वपूर्ण है। उन्होंने बीडब्ल्यूआर, तारापुर हेतु मिश्र ऑक्साइड ईंधन के रासायनिक अभिकल्पन में सक्रिय रूप से भाग लिया। उनके अन्य रुचिकर क्षेत्रों में विभवमापी, चयनात्मक आयन वाले विद्युत-विश्लेषणात्मक रसायनिकी शामिल हैं।

Mr. R.Govindan obtained his M.Sc. Degree in Chemistry from Annamalai University. He joined the Mass Spectrometry Section of the Fuel Chemistry Division, BARC, Mumbai after working at the Advanced Fuel Fabrication Facility, BARC, Tarapur for a period of 14 years. He is currently working in the field of inorganic Mass Spectrometry for precise isotopic analysis and concentration determination of elements which are important in nuclear technology. He actively participated in the chemical characterization of mixed oxide fuel for BWR, Tarapur. His other areas of interest include Potentiometry, Electro-analytical chemistry involving ion selective electrodes.



P.S. Khodade

श्री पी.एस. खोदाडे, ईंधन रासायनिकी प्रभाग, भापअ केंद्र, ट्राम्बे के मास स्पेक्ट्रोमिटर अनुभाग में वैज्ञानिक अधिकारी के रूप में कार्यरत हैं। वे 1975 से इनामॉनिक मास स्पेक्ट्रोमिटर तथा परिशुद्ध आईसोटोप विश्लेषण हेतु अल्फा स्पेक्ट्रोमिटर और घटकों के सांद्रण निदर्शन के क्षेत्र में कार्यरत हैं जो कि नाभिकीय प्रौद्योगिकी के क्षेत्र

में महत्वपूर्ण है। वे विभिन्न जर्नलों एवं संगोष्ठियों में प्रकाशित 50 वैज्ञानिक प्रकाशनों के सहलेखक हैं।

Mr. P.S.Khodade is working as a scientific officer in the Mass Spectrometry Section of the Fuel Chemistry Division, B.A.R.C, Trombay, Mumbai. Since 1975, he has been working in the field of inorganic Mass Spectrometry and Alpha Spectrometry for precise isotopic analysis and concentration determination of elements which are important in nuclear technology. He is a coauthor of 50 scientific publications in various journals and symposia.



Raju Shah

श्री राजू शाह ने मुंबई विश्वविद्यालय से रासायनिकी में बीएससी की डिग्री प्राप्त की। प्रशिक्षणार्थी (2005) के रूप में एक वर्ष पूर्ण करने के बाद उन्होंने मास स्पेक्ट्रोमिटर अनुभाग, ईंधन रासायनिकी प्रभाग, भापअ केंद्र, मुंबई में कार्यभार ग्रहण किया। वे आजकल आइसोटोपिक विश्लेषण एवं सांद्रण निदर्शन हेतु ताप आयनीकरण मास स्पेक्ट्रोमीटर के लिए कार्यरत हैं।

Mr. Raju Shah, obtained his B.Sc. degree in Chemistry from Mumbai University. After completing one year training (2005), he joined the Mass Spectrometry Section of the Fuel Chemistry Division, B.A.R.C., Mumbai. He is currently working with Thermal Ionization Mass Spectrometer for isotopic analysis and concentration determination.



Sasi Bhushan

श्री के. ससी भूषण ने आन्ध्र विश्वविद्यालय से रासायनिकी में बी.एससी की डिग्री प्राप्त की। प्रशिक्षणार्थी (2005) के रूप में एक वर्ष पूर्ण करने के बाद उन्होंने मास स्पेक्ट्रोमिटर अनुभाग, ईंधन रासायनिकी प्रभाग, भापअ केन्द्र, मुंबई में कार्यभार ग्रहण किया। वे आजकल आइसोटोपिक विश्लेषण एवं सांद्रण निदर्शन हेतु ताप

आयनीकृत मास स्पेक्ट्रोमीटर के लिए कार्यरत हैं।

Mr. K. Sasi Bhushan, obtained his B.Sc. degree in Chemistry from Andhra University. After completing one year training (2005) he joined the Mass Spectrometry Section of the Fuel Chemistry Division, B.A.R.C., Mumbai. He is currently working with Thermal Ionization Mass Spectrometer for isotopic analysis and concentration determination.



S.M. Yusuf

डॉ. एस.एम. यूसुफ़, ठोस अवस्था भौतिकी प्रभाग, भा.प.अ. केंद्र को दिनांक 14-16, फ़रवरी, 2008 के दौरान तिरुवनंतपुरम में आयोजित बैठक में मटीरियल रिसर्च सोसाइटी ऑफ़ इंडिया द्वारा एमआरएसआई पदक प्रदान किया गया।

सन 1989 में डॉ. एस.एम. यूसुफ़ ने भौतिकी में एक वर्षीय बीएआरसी ट्रेनिंग स्कूल ओरिएन्टेशन कोर्स पूर्ण करने के बाद भा.प.अ. केंद्र में वैज्ञानिक अधिकारी के रूप में कार्यग्रहण किया। वे मैग्नेटिज्म एवं पोलराइज्ड/अनपोलराइज्ड न्यूट्रॉन स्कैटरिंग तकनीकियों में विशेषज्ञता सहित उत्कृष्ट प्रयोगात्मक संघनित पदार्थ भौतिकी विद् हैं। वे भा.प.अ. केंद्र में मैग्नेटिज्म न्यूट्रॉन स्कैटरिंग ग्रुप का प्रतिनिधित्व करते हैं। उन्होंने मैग्नेटिक न्यूट्रॉन अध्ययनों हेतु एक पोलराइज्ड न्यूट्रॉन स्पेक्ट्रोमीटर स्थापित किया और वे भारत में न्यूट्रॉन डीपोलराइजेशन तकनीकों की स्थापना करने वाले और प्रयोग करने वाले पहले व्यक्ति हैं।

डॉ. यूसुफ़ इंडियन फ़िज़िकल सोसाइटी के प्रथम उत्कृष्ट युवा वैज्ञानिक पुरस्कार (1996), इंडियन फ़िज़िक्स एसोसिएशन का सत्य मूर्ति स्मारक पुरस्कार (1996) तथा डीईई साइंस रिसर्च कांऊंसिल आउटस्टैंडिंग रिसर्च इन्वेस्टीगेटर पुरस्कार (2005) के प्राप्तकर्ता हैं।

वे ओपन कन्डेन्सड मैटर फ़िज़िक्स जनरल, बेन्थम साइंस पब्लिशर्स-लिमिटेड के सम्पादकीय सलाहकार बोर्ड के सदस्य हैं। उन्होंने जून 1997 से जुलाई 1998 के दौरान आर्गोन नैशनल लैबोरेटरी, यूएसए में पोस्टडॉक्टरल फ़ेलो के रूप में कार्य किया और दिसम्बर 2004 से अप्रैल 2006 तक इंस्टिट्यूट ऑफ़ मटीरियल साइंस, ज़ेरागोज़ा, स्पेन में विज़िटिंग प्रोफ़ेसर के रूप में कार्य किया।

The Materials Research Society of India conferred the MRSI medal on Dr. S. M. Yusuf, Solid State Physics Division, BARC in the meeting held at Thiruvananthapuram during February 14-16, 2008.

Dr. S.M. Yusuf joined BARC as a Scientific Officer in the year 1989 after completing one year BARC Training School orientation course in Physics. He is an outstanding experimental condensed matter physicist with specialization in magnetism and polarized/unpolarized neutron scattering techniques. He leads the magnetic neutron scattering group at BARC. He set up a Polarized Neutron Spectrometer for magnetic scattering studies and was the first person in India to establish and use the neutron depolarization technique.

Dr. Yusuf is the recipient of the First Best Young Physicists Award (1996) of the Indian Physical Society, N.S. Sathya Murthy Memorial Award (1996) of the Indian Physics Association and the DAE Science Research Council Outstanding Research Investigator Award (2005).

He is the member of the editorial advisory board of Open Condensed Matter Physics Journals, Bentham Science Publishers Ltd. He worked as a postdoctoral fellow at Argonne National Laboratory, USA during June 1997- July 1998 and as a visiting professor at the Institute of Materials Science, Zaragoza, Spain during December 2004 - April 2006.



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