Large Hadron Collider: role of Jammu University*

The world's most powerful particle accelerator Large Hadron Collider (LHC) started working successfully at the CERN Laboratory, Geneva on 10 September 2008. It is the biggest international collaborative scientific effort involving about 8000 scientists from 111 countries across the globe. LHC is also the biggest machine of the world built in a 27 km long circular tunnel about 100 m below the ground underneath the Swiss–French border.

Scientists across the world have been working on this US$ 9.2 billion LHC experiment for the last 20 years. The experiment is designed to reveal the mysteries of the universe and its origin. It is aimed to re-create the conditions which existed in the universe during the big bang and just after one trillionth of a second after the big bang, by colliding two proton beams at very high energy. The experiment will also study the Higgs bosons, the smallest sub-atomic particles which are supposed to have made the universe along with other particles.

The LHC has four collision points at which four different detectors have been used. These detectors are ATLAS, CMS, ALICE and LHCb, which have been installed in four huge underground caverns located around the circular LHC.

In this international collaborative scientific enterprise, India too has contributed substantially. About 80 Indian scientists are involved in the experiment. India has spent more than 160 crores on this project. Indian experts from the Indore-based Raja Ramana Centre for Advanced Technology (RR-CAT) made and tested several components used in the beamline in the 27 km long tunnel at CERN. Indian scientists from the Tata Institute of Fundamental Research (TIFR), Mumbai and the Variable Energy Cyclotron Centre (VECC), Kolkata have also made certain detectors.

Among other contributions, India has a special role in the ALICE (A Large Iron Collider Experiment) of the LHC. ALICE is a specialized detector meant to analyse lead-ion collisions and to study the properties of quark–gluon plasma, a state of matter which probably existed just after the big bang, before particles such as protons and neutrons were formed.

ALICE has 18 different detectors which were made with international collaboration and some of these detectors are: Time Projection Chamber, Inner Tracking System with three sub-detectors, Transmission Radiation Detector, High Momentum Particle Detector, etc. All these detectors are meant for studying different aspects of physics.

'But Photon Multiplicity Detector (PMD) is one detector under the ALICE experiment which is purely of Indian origin', says Anik Gupta, Jammu University (JU), Jammu. He adds, 'PMD was made by Indian scientists only and no help of any sort was taken from outside. Even conceptualization of PMD has been done in India'.

Gupta further informed that after conceptualization of the PMD, the R&D work, computer simulations, physics simulations, fabrication, testing, data control system, detector control system, software analysis and data analysis have been purely an Indian effort.

Y. P. Vyogi (Director, Institute of Physics (IOP), Bhubneswar) was the Indian team leader for the PMD ALICE project. Under his leadership, the PMD was made in India. VECC was the nodal centre for various activities connected with the PMD.

'Fabrication of the PMD was done at three places (VECC, IOP and JU) in India, but 25% of its fabrication was done in a junk-room turned laboratory at JU', boasts Gupta, who along with his colleagues and students actually did the fabrication at JU.

The JU experts made the testing modules and all the printed circuit boards (PCBs) which were used in the fabrication of the PMD, consisting of 48 modules. Each module has two PCBs covering a honeycomb style copper mesh. 'We also made the *XYZ* testing set-up, which is a fully automated computerized leakage current measurement workstation', says Gupta.

'The *XYZ* measurement system was initially made at JU using the available materials like the wood, plywood, etc., with the help of a carpenter, and three stepper motors were coupled with the *X*, *Y* and *Z* axes and were interfaced with a computer. After conceptualization, we sought industry help from Ambala for the final set-up with a precision of 10 microns', says Gupta.

'We made the leakage current measurement system using a multimetre interfaced with a computer and by writing a programme for movement and current measurement. This was able to measure leakage current through 4000 solder points on a PCB, and that too without any manual interruption. This way, the initial quality control machine was made at JU', exclaimed Gupta. He also informed that wiring of one module took about one month and that their group at JU had made 12 such modules under the supervision of Sanjay Mahajan, which were sent to VECC for further testing and from there to the CERN laboratory in Geneva.

Gupta, who was responsible for developing, installing and commissioning the Detector Control System (DCS) for the PMD, is monitoring the control system of the PMD installed at CERN via internet from his office at JU.

The ALICE detector is generating data at a speed of 1.2 GHz per second, which is being stored at CERN. Such a huge quantity of data cannot be stored at one place. So the concept of GRID came into existence. In the GRID system, big clusters of computers are interlinked via high-speed internet. 'We access these data via internet and download some files at our local system for analysis', informed Gupta. 'We [JU] also wanted to be a part of the GRID, but we don't have the required infrastructure like high-speed internet and uninterrupted 100% power supply here at JU'.

The 25 member team of scientists, engineers and computer experts from JU is the largest from the Indian universities. Other institutions involved in the PMD project are IIT-Mumbai; Panjab University, Chandigarh, and Rajasthan University, Jaipur.

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*Based on a conversation with Anik Gupta, Project Engineer at Jammu University.