

India Celebrates Breakthrough Prize in Fundamental Physics Awarded to Large Hadron Collider Experiments

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The 2025 Breakthrough Prize in Fundamental Physics is awarded to co-authors of publications based on CERN's Large Hadron Collider Run-2 data released between 2015 and July 15, 2024, at the experimental collaborations ATLAS, CMS, ALICE and LHCb. The \$3 million prize is allocated to these four experiments at CERN and will be used by the collaborations to offer grants for doctoral students from member institutes to spend research time at CERN, giving the students experience working at the forefront of science and new expertise to bring back to their home countries and regions. 5,345 researchers were involved in ATLAS; while 4,550 researchers in CMS; 1,869 researchers in ALICE; and 1,744 researchers were involved in LHCb.

Indian scientists and researchers have played a significant role in the international collaboration for the ALICE (A Large Ion Collider Experiment) and the CMS (Compact Muon Solenoid) experiments. Several Indian institutes, universities, and scientists have contributed both intellectually and technically to the experiment's success. From detector development to data analysis, various teams of Indian researchers have been actively involved at every stage of the experiments, right from their inception. These contributions underscore India's commitment to global scientific collaboration and its pivotal role in the success of the LHC experiments.

This prestigious award honours the collaborative and transformative research efforts that deepened our understanding of the Higgs boson, the quark-gluon plasma, matter-antimatter asymmetry, and physics beyond the Standard Model. Scientific teams belonging to several institutes from across the world have been working in a collaborative manner to achieve the objectives of the CERN experiments. India, a committed and active partner in the LHC program, proudly acknowledges this international recognition and celebrates its significant contributions to the experiments and the LHC infrastructure.

About the LHC

Operated by CERN, the Large Hadron Collider is the world's most powerful particle accelerator, enabling high-energy proton and heavy-ion collisions to explore the structure of matter at the smallest scales.

India's involvement with CERN dates back to the 1960s, when scientists from the Tata Institute of Fundamental Research (TIFR) visited CERN to expose emulsion stacks to pion, kaon and proton beams utilizing the CERN Proton Synchrotron. Later, during the 1980s there was contribution towards hardware and core-software for the L3 – one of the four large experiments in the Large Electron Positron Collider (LEP) and significant contributions in the areas of Z-line shape (related to Neutron, Proton ratio in nuclei)

and new particle searches. In the 1990s, the collaboration expanded into heavy ion physics, with Indian groups contributing a scintillator-pad-based photon multiplicity detector. Indian teams played key roles in the WA93 and WA98 experiments at CERN-SPS, achieving early measurements of collective flow and exploring disoriented chiral condensates.

In 1991, India (DAE) signed a cooperation agreement with CERN for development of Scientific and Technical Cooperation in the Research Projects of CERN, with a formal cooperation agreement signed in 1991. This was further strengthened by a Memorandum of Understanding (MOU) signed in 2009, laying the groundwork for expanded collaboration in accelerator technology, detector R&D, computing infrastructure, and human resource training. The agreement also facilitates joint research and greater Indian participation in CERN's long-term projects.

In recognition of the significant Indian contributions towards the LHC project, India was awarded the "Observer" status in 2002 and finally, India became an Associate Member State of CERN in 2017. India has been a committed and active partner in the LHC program of CERN and proudly acknowledges this international recognition while celebrating its significant contributions to the experiments and the LHC infrastructure.

As a testament to the long-standing scientific collaboration between India and CERN, in June 2004, India gifted a 2m tall statue of the Indian deity Shiva Nataraja, the Lord of Dance to CERN. In choosing the image of Shiva Nataraja, the Indian government acknowledged the profound significance of the metaphor of Shiva's dance, drawn by Carl Sagan for the cosmic dance of subatomic particles, which is observed and analysed by CERN's physicists. This statue is a standing example of the fusion of technology with cultural traditions. A quote of the world-renowned physicist, Fritjof Capra is inscribed on a plaque alongside the statue which reads as, "Hundreds of years ago, Indian artists created visual images of dancing Shivas in a beautiful series of bronzes. In our time, physicists have used the most advanced technology to portray the patterns of the cosmic dance. The metaphor of the cosmic dance thus unifies ancient mythology, religious art and modern physics."

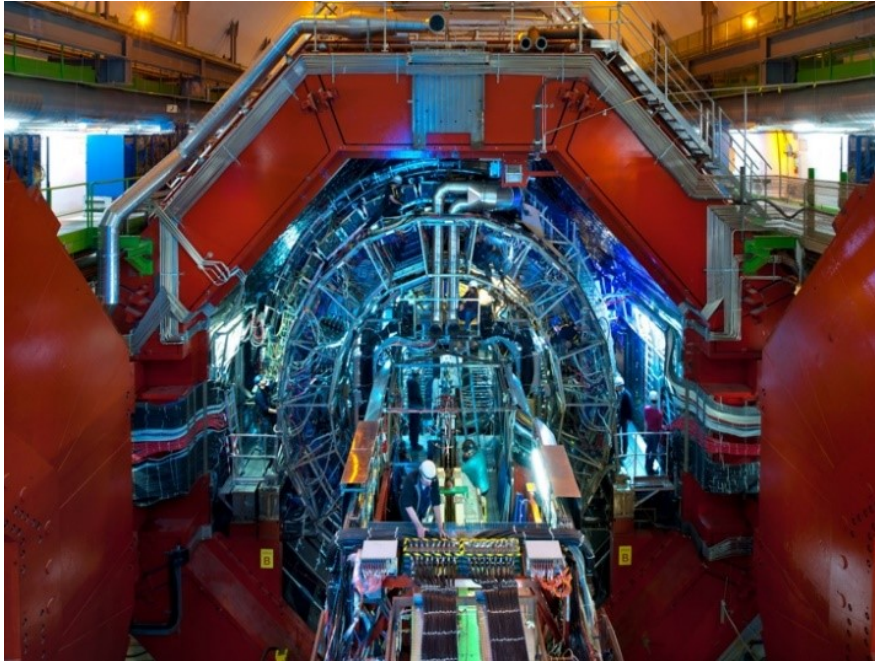


The Nataraj Statue at CERN

India's involvement spans all layers of the LHC program—from accelerator technology to major physics experiments—through national support from the **Department of Atomic Energy (DAE)** and the **Department of Science and Technology (DST)**. India actively participates in the governance and decision-making processes for various

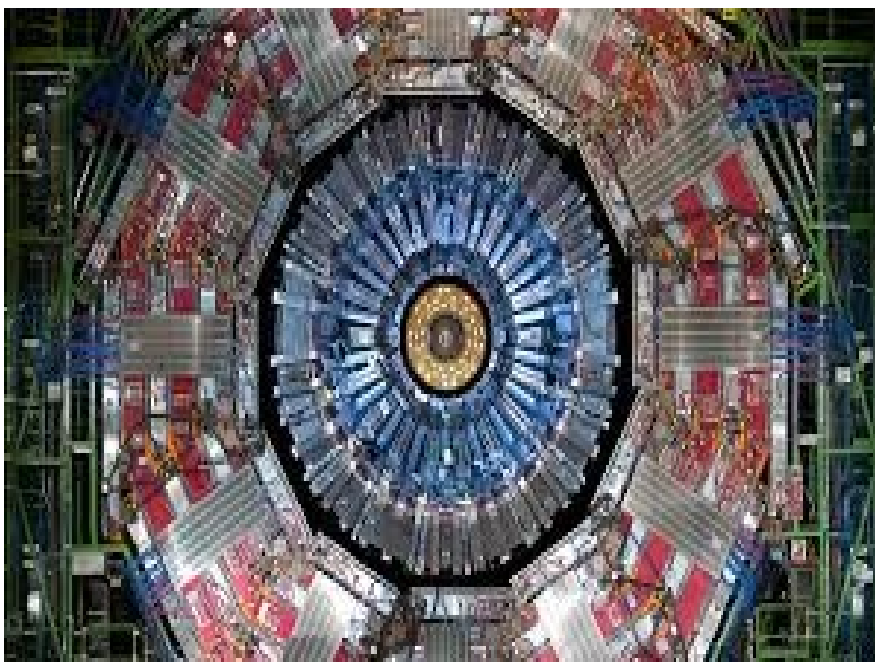
experiments being conducted and planned at CERN. Indian scientists and institutions are also represented on prominent CERN boards and committees, including **Research and Resources Board (RRB)**, **Advisory Committee of CERN Users (ACCU)** and **Scientific Council**.

The ALICE collaboration in India includes VECC-Kolkata, SINP-Kolkata, IOP-Bhubaneswar, Aligarh Muslim University, IIT-Mumbai, Panjab University, University of Jammu, University of Rajasthan (till 2021), Bose Institute, Guwahati University, Jadavpur University, *NISER-Bhubaneswar*, *IIT-Indore*, *Coochbehar Panchanan Barma University*, *IISER-Berhampur* and *University of Kashmir*.



ALICE Experiment

The CMS collaboration in India includes Delhi University, Institute of Physics, IISc Bengaluru, IISER-Pune, Panjab University, UIET- Panjab, IIT-Bhubaneswar, IIT-Chennai, BARC-Mumbai, NISER-Bhubaneswar, PAU-Ludhiana, SINP-Kolkata, TIFR-Mumbai, IIT-Hyderabad, IIT-Kanpur, IIT-Mandi, IISER-Mohali, Visva-Bharati University, UoH-Hyderabad, BIT-Mesra, Amity University and BN Mondal University-Madhepura, Bihar.



CMS Experiment

Indian teams from BARC, Mumbai and RRCAT, Indore have contributed significantly to the construction of LHC that includes high-precision components for **cryogenics, superconducting magnets, and beam instrumentation**, design and fabrication of **collimators, vacuum chambers, and radio-frequency systems**. These contributions enabled stable and high-energy collisions essential for the discoveries recognized by the Breakthrough Prize.

Indian team in ALICE have played pivotal leadership roles in the ALICE collaboration, particularly in the areas of **detector design** and **data analysis**. Indian scientists designed and constructed and commissioned ingeniously the **Photon Multiplicity Detector (PMD)** and **Muon Spectrometer**, vital for studies of quark gluon plasma. They led key analyses on **event –by-event fluctuations, resonance production, collective flow, and heavy-flavour production**.

The CMS Indian team contributed significantly to design the **trigger and data acquisition systems**, and provided critical components such as **Resistive Plate Chambers (RPCs), Silicon Preshower Detector, and Hadron Outer (HO) Calorimeter**. The team led important studies in **Higgs boson searches, top-quark, flavor physics, electroweak measurements, supersymmetry, and other BSM (beyond Standard Model) searches**, while supporting Tier-2 data processing for global collaboration.

India has also played a vital role in the **Worldwide LHC Computing Grid (WLCG)**—a global network that processes and analyses the vast data generated by LHC experiments. Indian Tier-2 centres, notably at **TIFR Mumbai** and **VECC Kolkata**, have been central to providing computing and storage resources: **WLCG-India** hosts 17400 cores computing and 12 PB of storage having supported over **17.5 million ALICE jobs** in 15 years. Indian scientists also contributed to software and tools used across the grid, such as **GRIDVIEW** (monitoring) and **SHIVA** (problem tracking), contributing over **1,000 person-months** of effort during key development phases.

Large number of Indian students are trained annually through active participation in ALICE and CMS experiments, including on-site work at CERN. They gain exposure to advanced instrumentation, scientific computing, international collaboration, and frontier of physics research. India's engagement during LHC Run 2 has led to more than **110 Ph.D. theses** and more than **130 publications in peer-reviewed journal papers** based on ALICE and CMS data. Indian Scientists plays important leadership in **physics analysis, detector R&D, and machine learning applications**.

"This recognition from the Breakthrough Prize Foundation is a tribute to decades of scientific perseverance and international unity. India's researchers, students, and engineers have been proud partners in this discovery journey," said, Dr. A.K. Mohanty, *Chairman Atomic Energy Commission and Secretary, Dept. of Atomic Energy*.

Prof. Abhay Karandikar, *Secretary, Department of Science and Technology* noted that the Indian researchers have contributed profoundly towards LHC experiments. While congratulating the team, he mentioned that "the Breakthrough Science Award 2025 for these experiments establishes the prominence of Indian S&T contribution and their role in furthering the fundamental research".

India is now gearing up to contribute to the **p-type Silicon** based Forward Calorimeter (FoCal) detector in ALICE—that will enable precision measurements of direct photons and neutral pions at forward rapidities, unlocking new windows to know the structure of protons and nuclei. Indian team is contributing significantly to the CMS Phase-2 upgrade in four subdetector components, namely, **Outer Tracker (OT), Gas Electron Multiplier (GEM), High Granular Calorimeter (HGCal), and Trigger system**.

These upgraded detectors are essential for high-luminosity LHC (HL-LHC) experimental running conditions, which is aimed at achieving precision physics results and looking for physics beyond Standard Model.

The Breakthrough Science Award 2025 is a shared honour—celebrating not just the ALICE and CMS collaboration but the spirit of international science, powered by dedicated individuals and visionary support systems. As ALICE and CMS enters a new era, India stands proudly as both a contributor and a beneficiary—fuelling discoveries that may forever reshape our understanding of the universe.

SC/PK

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