Department of High Energy Physics

Annual Meeting 2016

Sudeshna Banerjee

TIFR, Mumbai

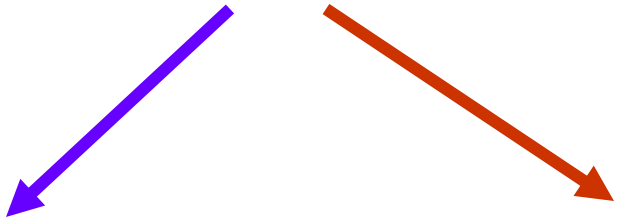
April 7, 2016

Members

- Academic – 13
- Scientific Officers – 45
- Students – 18
- Total strength > 100
- Field stations – Hanle, Gauribidanur, Madurai, Ooty
- Foreign Collaborations – CERN (CMS), Fermilab (D0, CMS), KEK (BELLE)

Path to High Energies

Particles need to be accelerated



Man made accelerators

synchrotrons

Several on earth

Natural Accelerators

Cosmic rays

Several in the sky

Physicists Find Elusive Particle Seen as Key to the Universe

By DENNIS OVERBYE 8:18 PM

Researchers said they had discovered what looked for all the world like the Higgs boson, long-sought particle that

HIGGS EXISTS

Englert

Higgs

'Typical! I've found the Higgs boson, but I've lost my glasses again'

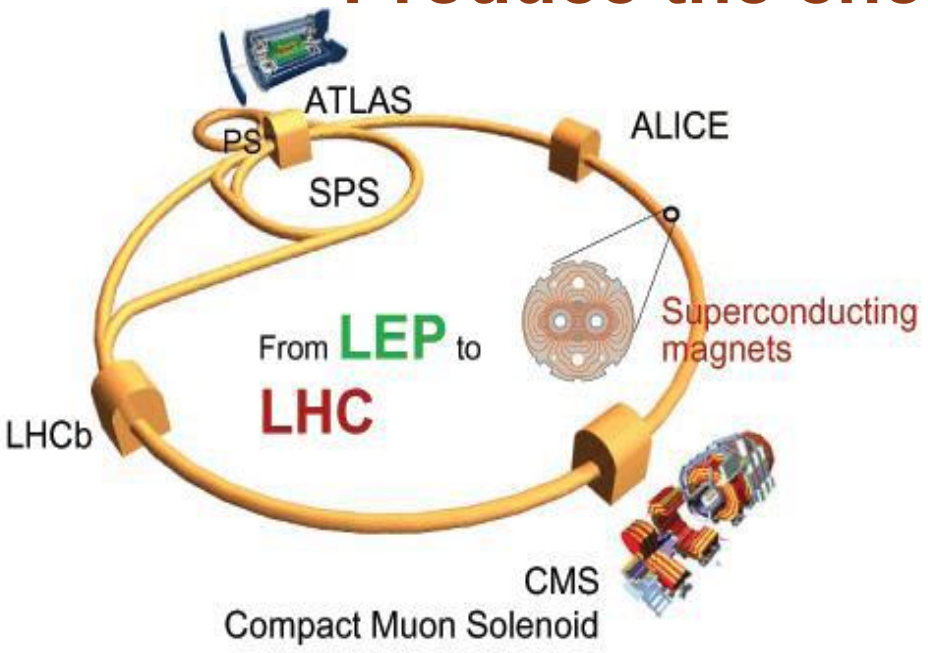
CERN Site

Geneva, Switzerland

The Large Hadron Collider (LHC)

(Geneva, Switzerland)

Produce the energ



LHC Tunnel

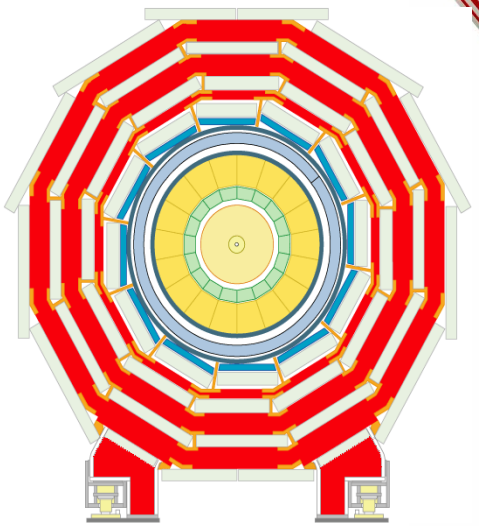
- Circumference = 27 Km(16.8 miles)
- 100 metres underground
- Luminosity = no. of collisions per unit area per unit time
- Integrated luminosity over a period of time is expressed in units of barn^{-1} (1/area)

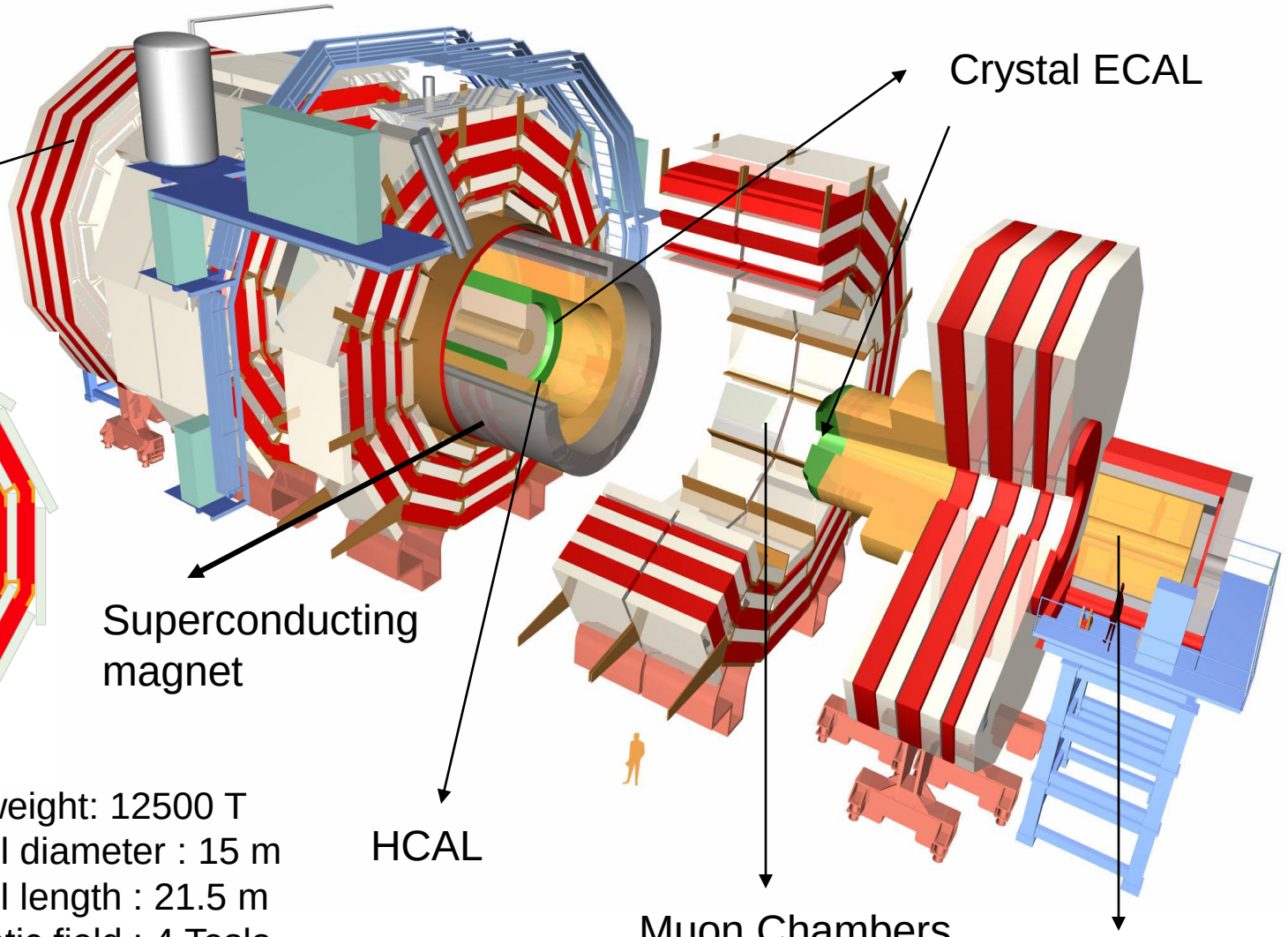
	Beams	Energy GeV	Luminosity	
LEP	e+ e-	200	10^{32} cm^{-2}s^{-1}	
LHC	p p	14000	10^{34}	NOW
	Pb Pb	1,312,000	10^{27}	

Upto 2013 8 TeV ~0.6 10^{33}

CMS – Compact Muon Solenoid

37 countries, 155 institutes, 2000 scientists (including 400 students)

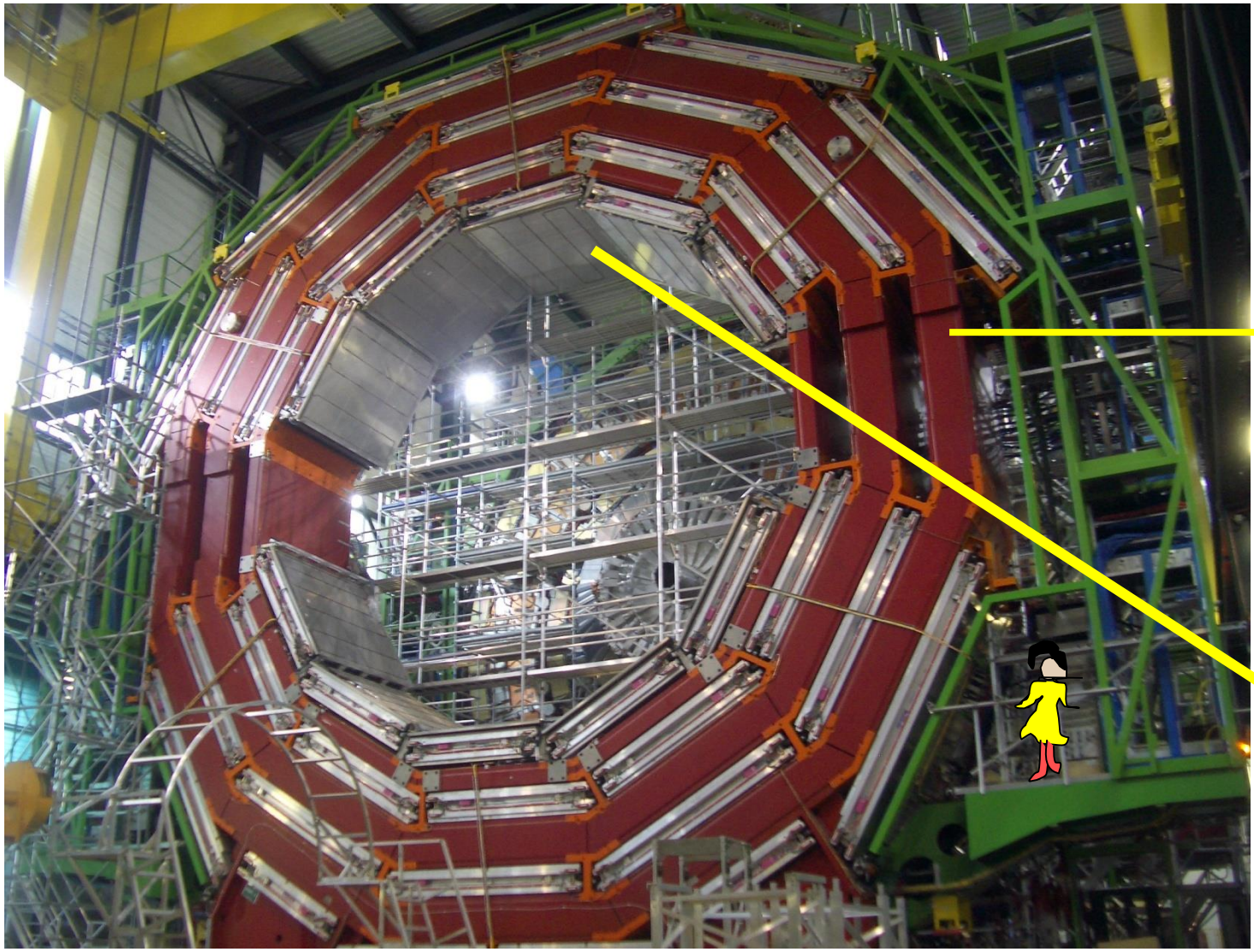




Total weight: 12500 T
Overall diameter : 15 m
Overall length : 21.5 m
Magnetic field : 4 Tesla

(Placed at 100 m underground)

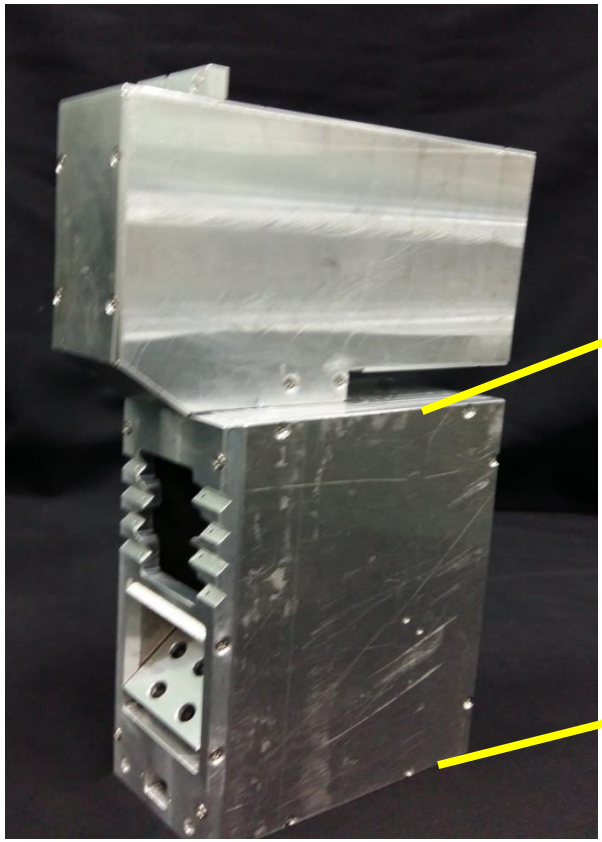
CMS Detector – Hadron Barrel Calorimeter

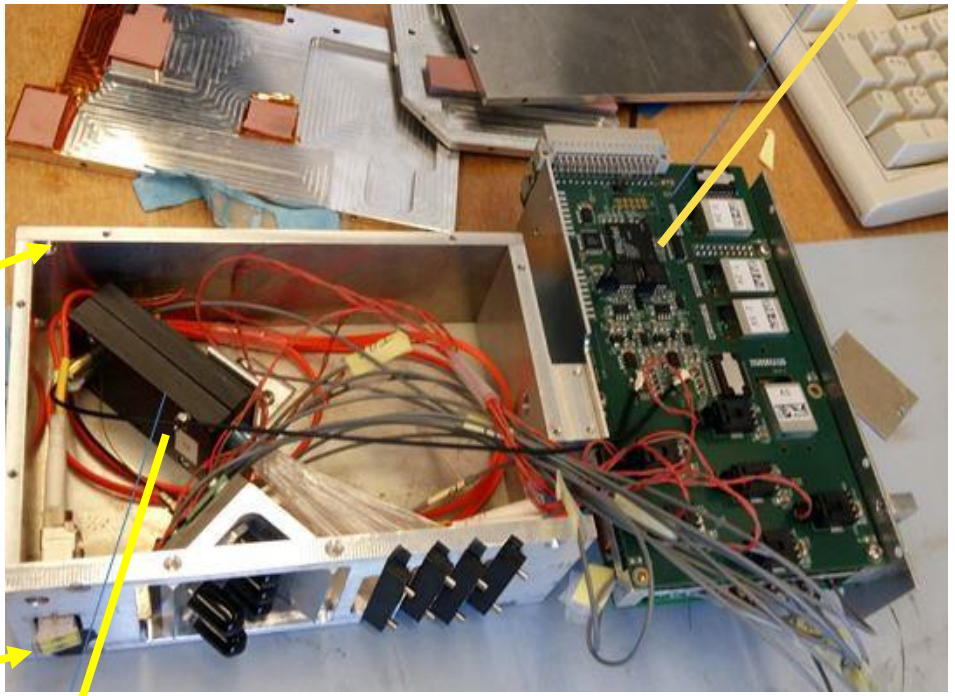


Calibration Unit for Hadron Calorimeter

Monitor radiation damage

Mechanics of the Al CU Box
TIFR workshop





Pulser board

Light Mixer optics

S. Banerjee, M. Guchait,
G. Majumder, K. Mazumdar, M. Patil

India-CMS T2 grid computing center at TIFR

Location → **CG-17**

Apr 7, 2016

Pledged Resources (2015)

Site Name	VO	Pledge Type	Resources pledged	% of required resource in CMS
T2_IN_TIFR	CMS	CPU (HEPSPEC06)	6150	1%
		Disk (TB)	940	3%

- TIFR hosts a Grid Tier2 centre for CMS experiment
- 1 of the 50 T2 centres world-wide, 1 one of the earlier T2 centres in Asian region
- Active since 2008 (earning credit for the contribution made to CMS computing efforts)
- National contribution from India to CMS
- Average availability and reliability: ~ 90%

Pledge Resources for 2016

Site Name	VO	Pledge Type	Resources Pledged	% of required resource in CMS
T2_IN_TIFR	CMS	CPU HEPSPEC06	12,288	2%
		Disk (TB)	1,980	5%

Silicon Photomultiplier Activities

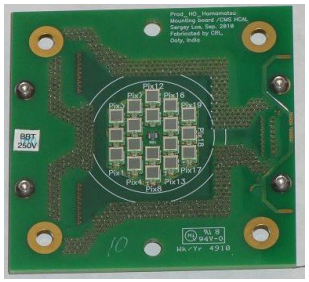
S. Dugad etal.

Upgrade of HO Detector with SiPM

- **Validation of SiPM for CMS environment**
  - Testbeam studies, stability, radiation hardness, magnetic field immunity, and saturation effects
- **Fabrication of 160 SiPM Control Boards at CRL, Ooty, India**
  - Each board has 18 Channels
  - Control boards provides generates bias voltage for each channel, monitors current, temperature etc.
  - Entire production and quality control of 160 boards to be carried by Indian group in India
- **Quality Control of Control Boards and SiPM Boards (160+160) at India:**
  - Setting up stand-alone DAQ system for Control and SiPM boards
  - Development of software for QC Data Analysis
  - Generating QC report for each board
- **Installation and Commissioning:**
  - Removal of 132 Readout Modules, Assembly of Readout Modules, QC and burn-in test at CERN, Installation of 132 Readout Modules
- **Project Leaders for Fabrication:**
  - Jim Freeman (FNAL) and Shashi Dugad (TIFR)
  - *Funded by TIFR, FNAL, DESY*

HO Readout Module Assembly

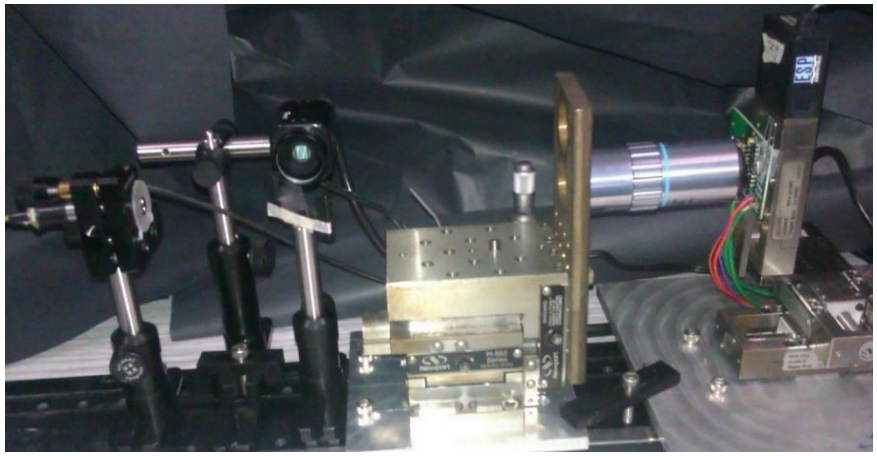
SiPM Control Board



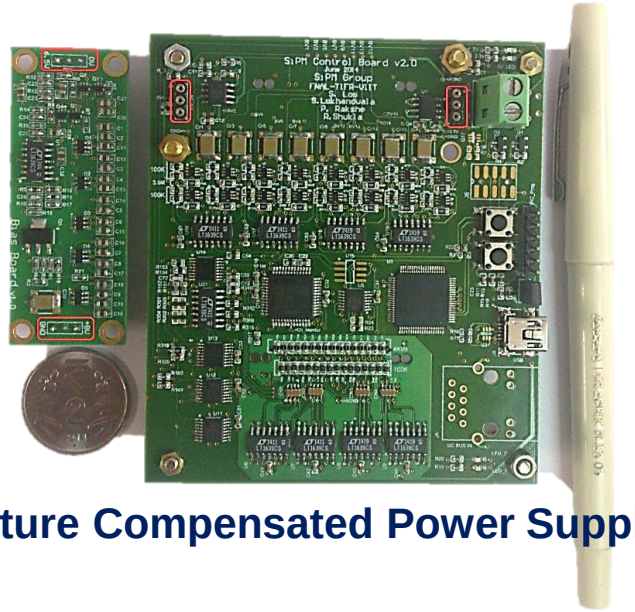
SiPM Mounting Board

In-house development

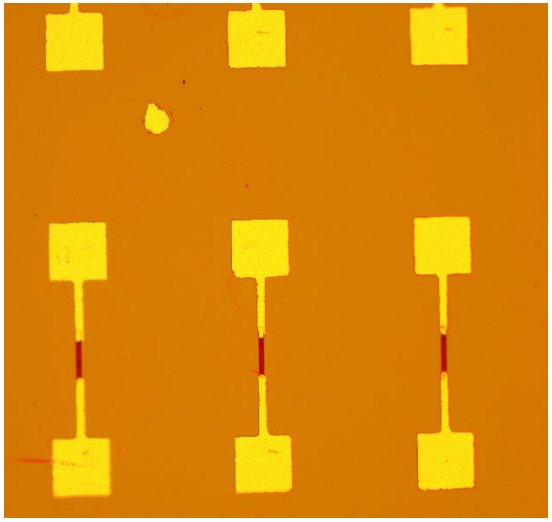
S. Dugad etal.



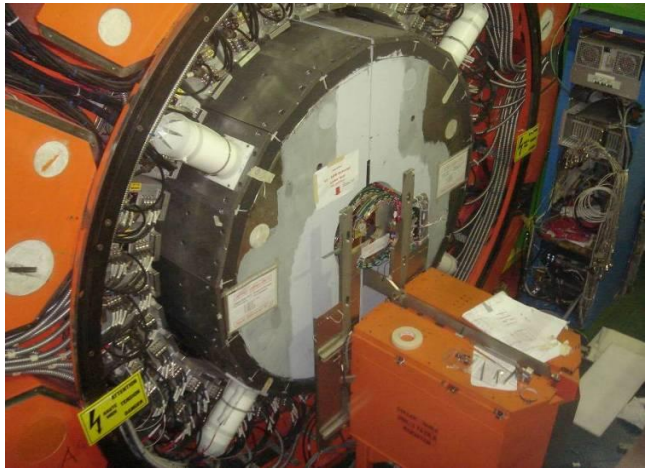
Micron Resolution Optical Scanner



Temperature Compensated Power Supply for SiPM



Fabrication of Poly-silicon resistors for SiPM

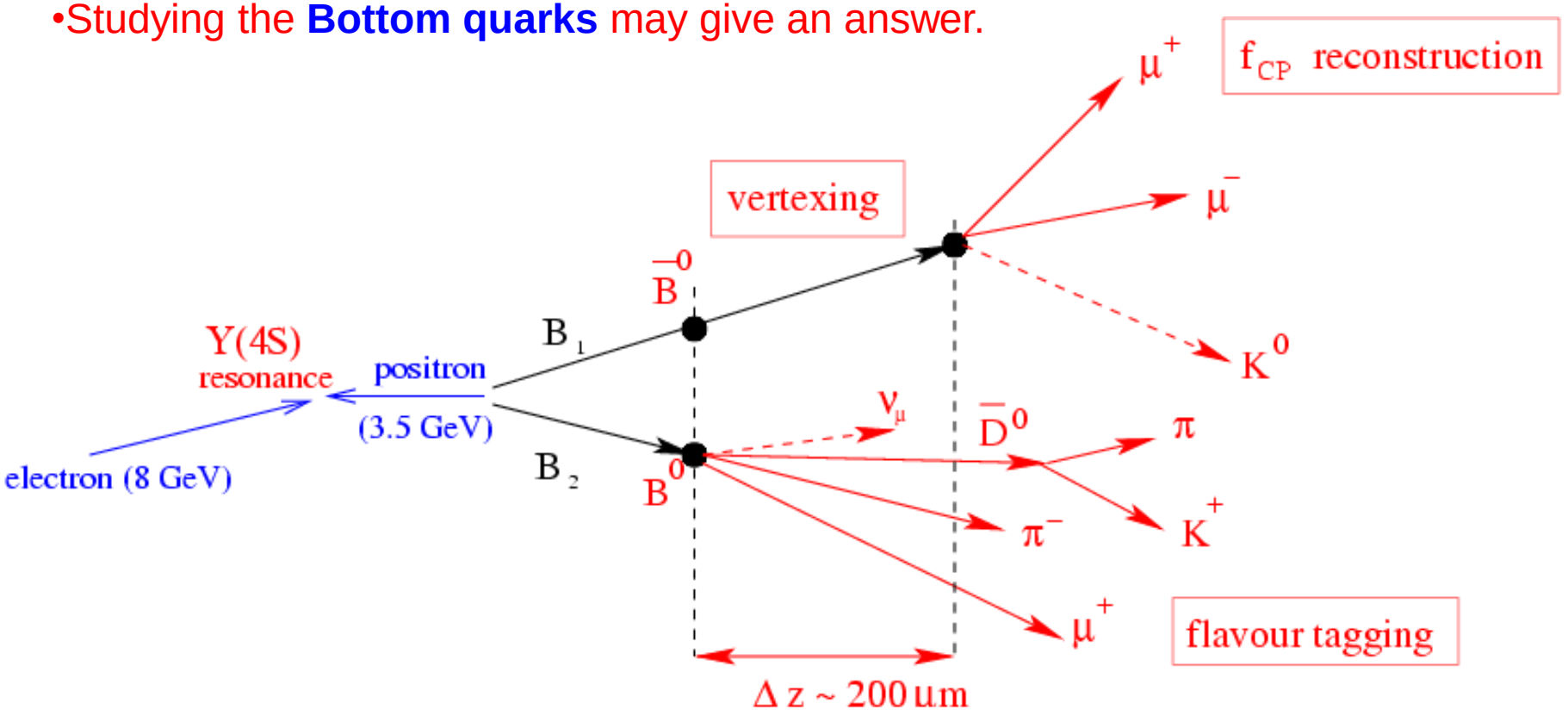


Data Acquisition System for HF Radiation Monitors at CMS

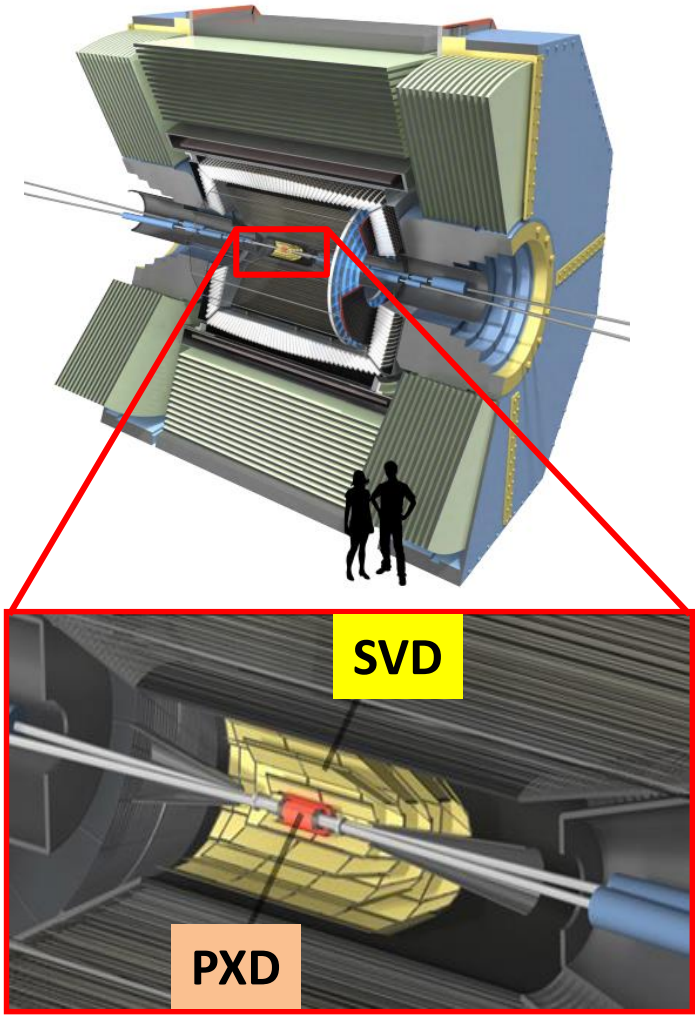
Belle Experiment at KEK lab, Japan

(T. Aziz, G. Mohanty etal.)

- Universe is made of nuclear matter – protons, neutrons and electrons.
- In the laboratory we can produce antiparticles of these. E.g. positron, antiproton.
- When matter meets antimatter they annihilate each other.
- So, why do we see a matter dominated universe ? Why this asymmetry ?
- Studying the **Bottom quarks** may give an answer.



Belle II Vertex Detector



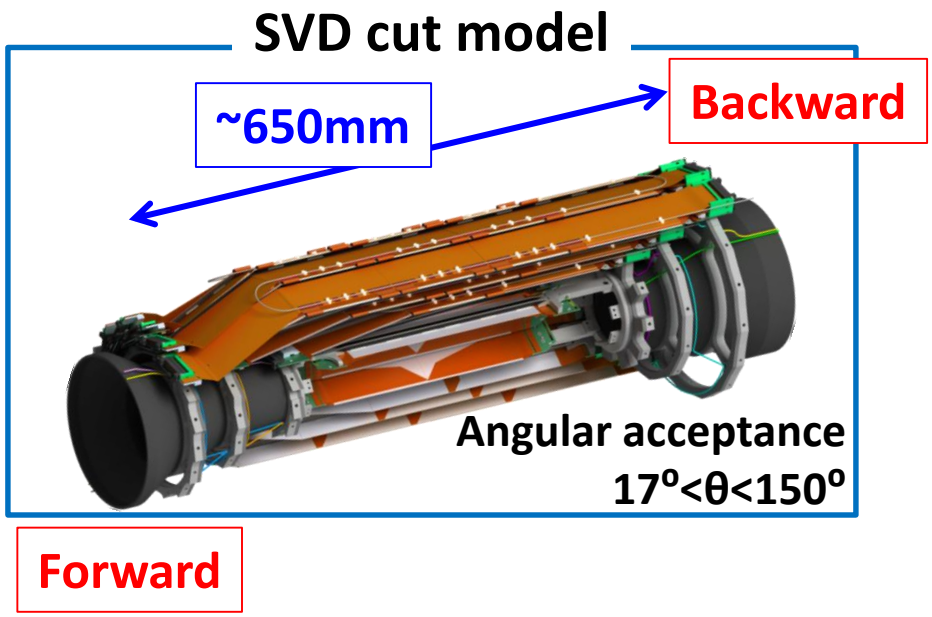
- **Determine the vertex positions of the weakly decaying particles**
- **Measure the two-dimensional track position and momentum for charged particles**

- PiXel Detector (PXD)
- Silicon Vertex Detector (SVD)
  - Double-sided silicon strip detectors

VXD Requirements

- Fast – to operate in a high rate environment
- Excellent spatial resolution
- Radiation hard (up to 100 kGray)
- Good tracking capability – to track particles down to 50 MeV in p_T

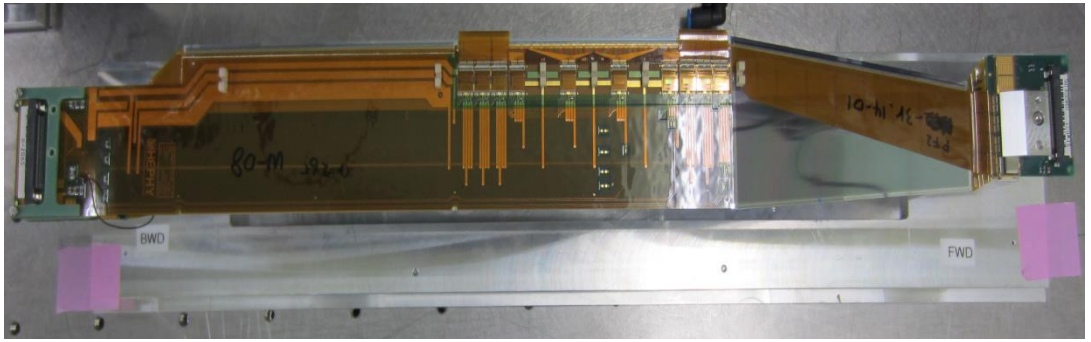
SVD in brief



Layer	Responsible institute
3	Univ. of Melbourne
4	TIFR, Mumbai
5	HEPHY, Vienna
6	IPMU, Japan

- 4 SVD layers (L3 to L6) composed of ladders arranged in a windmill structure
- Improved resolution at IP w.r.t Belle
- Very lightweight – only 0.58%X_0 per layer

A fully-working L4 prototype



Natural Accelerators

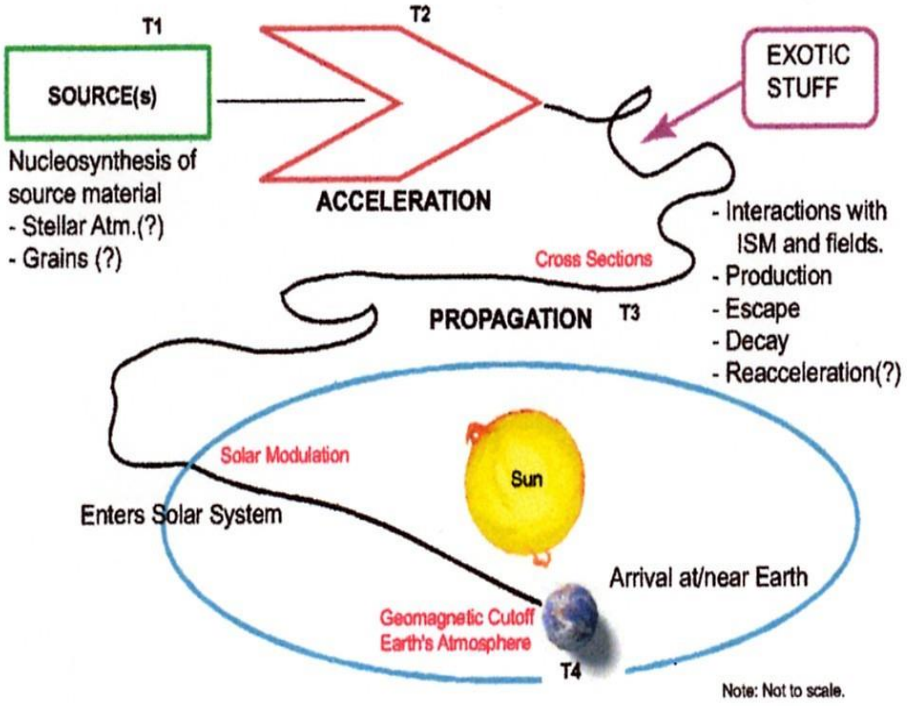
Celestial Sources

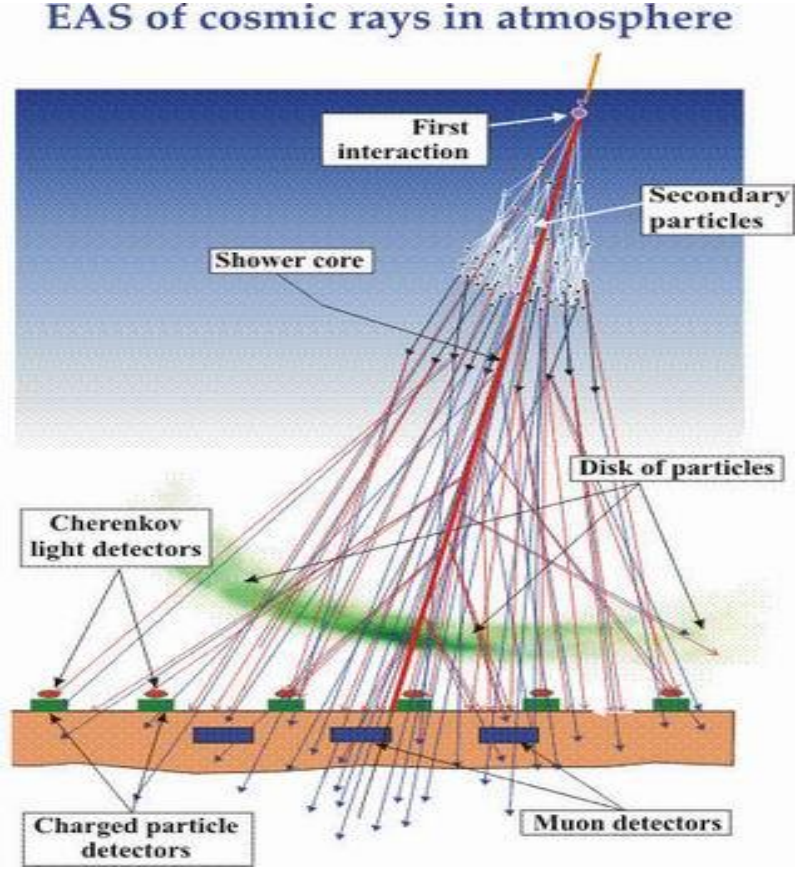
GRAPES

HAGAR

INO

Cosmic Rays





- **Cosmic rays are highest energy particles (10^8 – 10^{20}eV) present in nature.**
- **They bring valuable information about high energy astronomical phenomena.**
- **They play a major role in the evolution of galaxy**

GRAPES-3 Experiment
(Gamma Ray Astronomy at Pev EnergieS)

(S.K. Gupta, S.R. Dugad, P.K. Mohanty etal.)

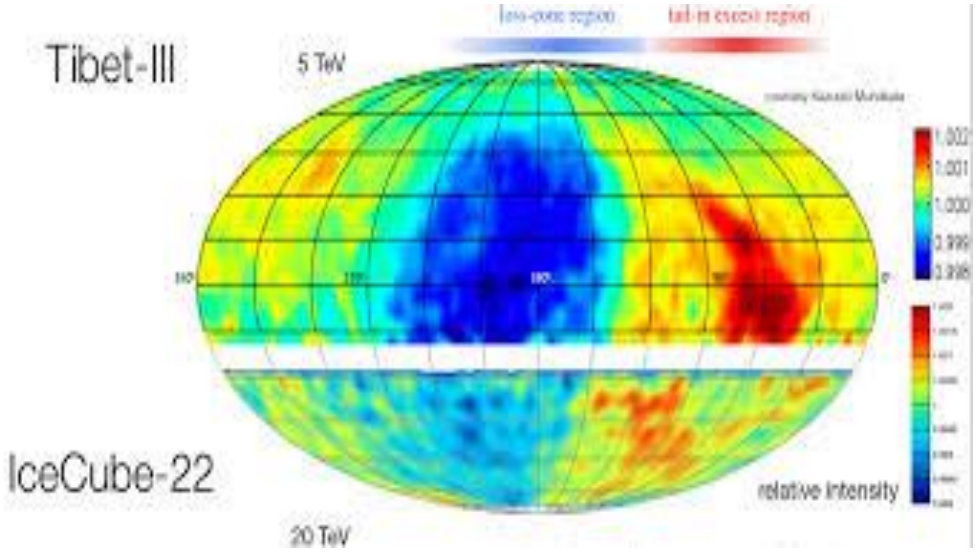
1. Tata Institute of Fundamental Research, Mumbai, India
2. Osaka City University, Osaka, Japan
3. Aichi Institute of Technology, Toyota, Japan
4. J.C. Bose Institute, Kolkata, India
5. Indian Institute of Sci. & Engineering Res. Pune, India
6. Indian Institute of Technology, Kanpur, India
7. Chubu University, Kasugai, Aichi, Japan
8. Hiroshima City University, Hiroshima, Japan
9. Kochi University, Kochi, Japan
10. Aligarh Muslim University, Aligarh, India
11. North Bengal University, Siliguri, India
12. Vishwakarma Inst. of Information Tech., Pune, India

S.K. Gupta, H.M. Antia, K.P. Arunbabu, S.R. Dugad, B. Hariharan, I. Mazumdar, P.K. Mohanty, P.K. Nayak, P. Jagadeesan, A. Jain, S.D. Morris, B.S. Rao, L.V. Reddy, Y. Hayashi, S. Kawakami, S. Ogio, H. Kojima, S. Das, S.K. Ghosh, S, Raha, P. Joarder, P. Subramanian, P. Jain, A. Oshima, S Shibata, K. Tanaka, T. Nakamura, S. Ahmad, A. Bhadra, R.K. Dey, C.S. Garde

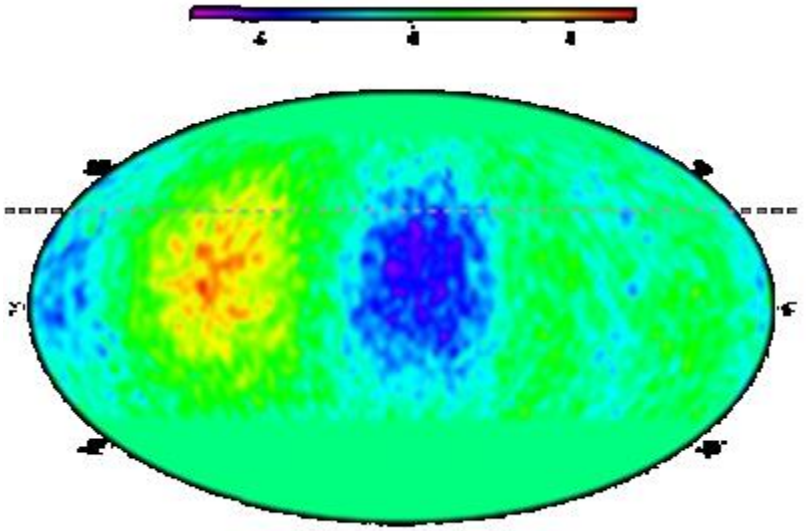
1050 PRCs fabricated out of required 3780 PRCs

Proportional counter Test Setup

Large Scale Anisotropy



Southern sky

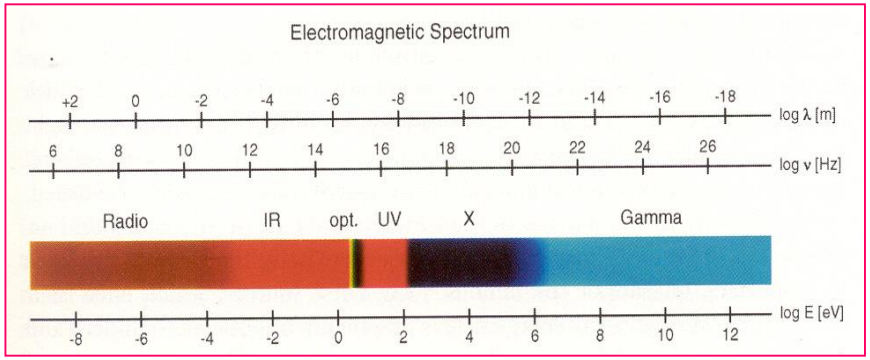


GRAPES-3 >10TeV

Ground-based Gamma-ray Astronomy at Hanle

B.S. Acharya, V. Chitnis etal.

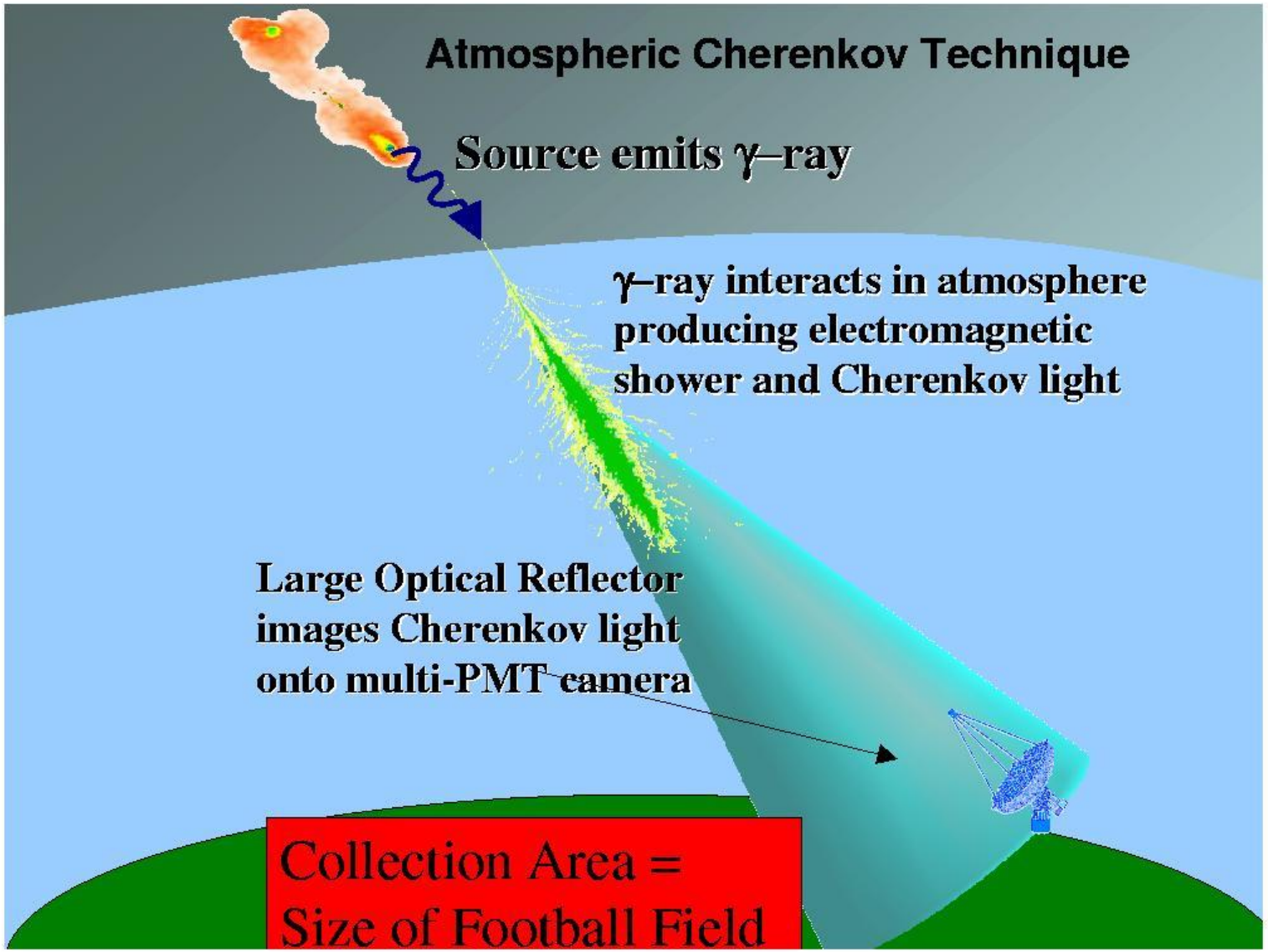
High Energy Gamma-ray Astronomy



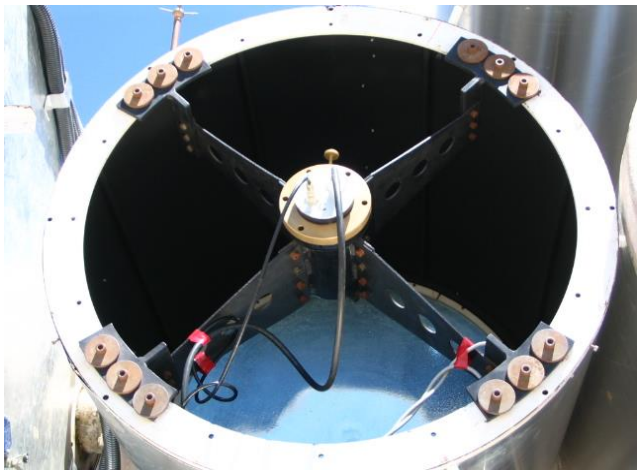
- Gamma-ray astronomy deals with highest energy photons from space.
- It gives a perspective of non-thermal universe which compliments our view from other spectral windows.
- Gamma radiation is generated under extreme conditions in objects or phenomena like black holes and violent explosions (supernova, hyper-nova, gamma-ray bursts etc) seen across the universe.
- Nature of TeV sources are extra-ordinary. Every source is evidence for a Cosmic Particle Accelerator
- Detection techniques are simple, ground-based and relatively inexpensive

A joint project of IIA Bangalore, TIFR, ApS Division BARC

Ground Based Gamma Ray Astronomy with Cherenkov Telescopes



HAGAR Telescope Array

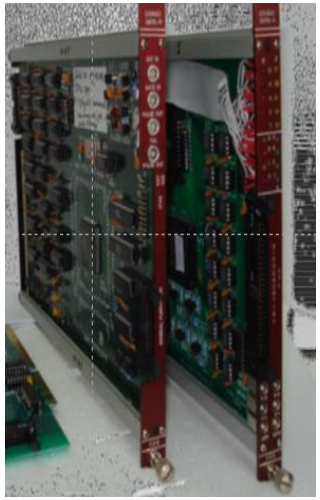


Array of 7 telescopes
at Hanle in Himalayas

Installation during 2005-2008
Energy threshold ~ 210 GeV
Total observation duration
(Sept, 2008 – March, 2015) :
3940 Hours

Modules Developed In-House

CAMAC controller



16 ch. CAMAC Latch

16 ch. CAMAC Scaler

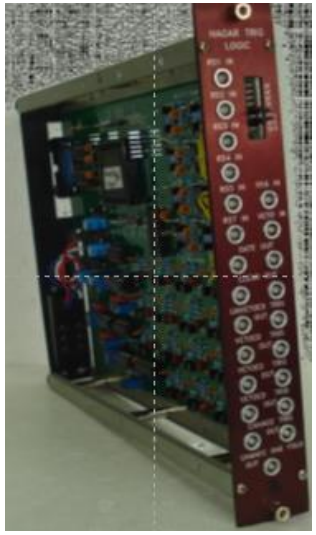
CAMAC Real Time Clock

NIM to ECL Converter

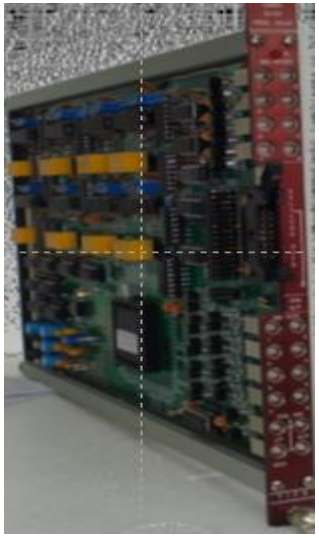
ECL Delay Generator

Programmable Discriminator

HAGAR Trigger Logic



Programmable Delay Generator



VME RTC

HAGAR : Recent Results

1. **Detection of Crab nebula at 18σ significance level**
2. **Detection of pulsations from Crab at 6σ level**
3. **Detection of flare from Mkn 421 in February 2010**
4. **Long term study of Mkn 421**
5. **Detection of Mkn 501 in high state**

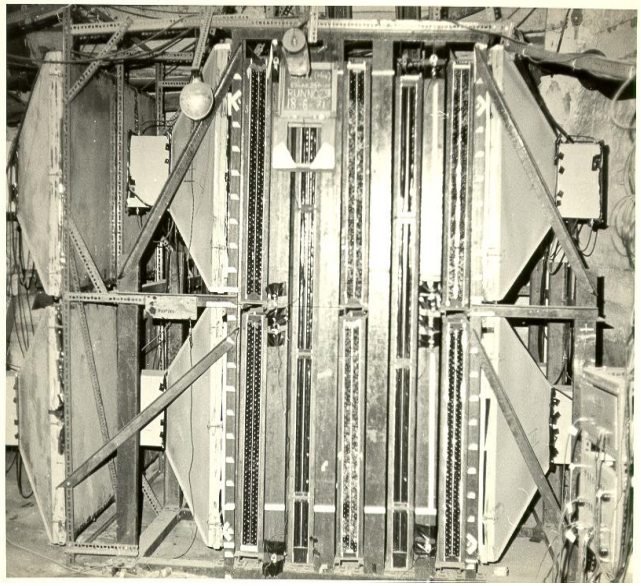
Other Ongoing Projects

1. **Development of G-APD based imaging camera**
2. **Development of calibration device for CTA**
3. **Development of software for CTA**

India Based Neutrino Observatory (INO)

Study of Atmospheric Neutrinos

Atmospheric neutrino detector at Kolar Gold Field –1965



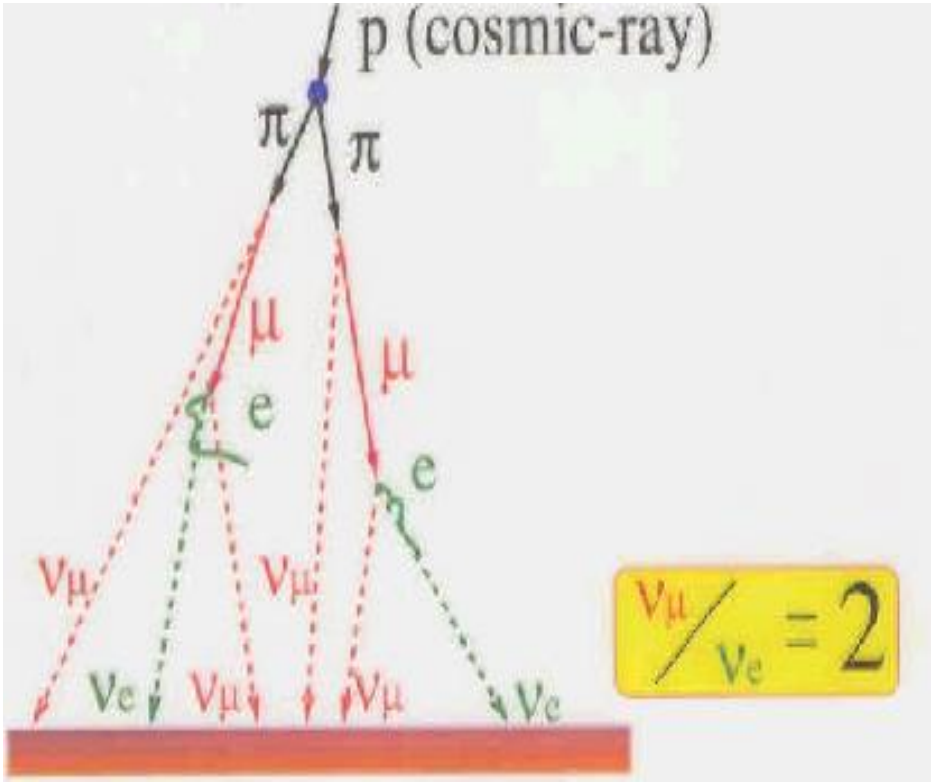
DETECTION OF MUONS PRODUCED BY COSMIC RAY NEUTRINO DEEP UNDERGROUND

C. V. ACHAR, M. G. K. MENON, V. S. NARASIMHAM, P. V. RAMANA MURTHY and B. V. SREEKANTAN,
Tata Institute of Fundamental Research, Colaba, Bombay

K. HINOTANI and S. MIYAKE,
Osaka City University, Osaka, Japan

D. R. CREED, J. L. OSBORNE, J. B. M. PATTISON and A. W. WOLFENDALE
University of Durham, Durham, U.K.

Received 12 July 1965



INO Sites

THE SITE: Bodi West hills at Pattipuram near Devaram in Theni district,

Inter-Institutional Centre for High Energy Physics (IICHEP), Madurai

The primary goal of INO is neutrino physics.

A national collaboration of scientists from about 25 groups belonging to DAE institutions, IITs and Universities.

The total cost of the project is expected to be about Rs.1500 crores.

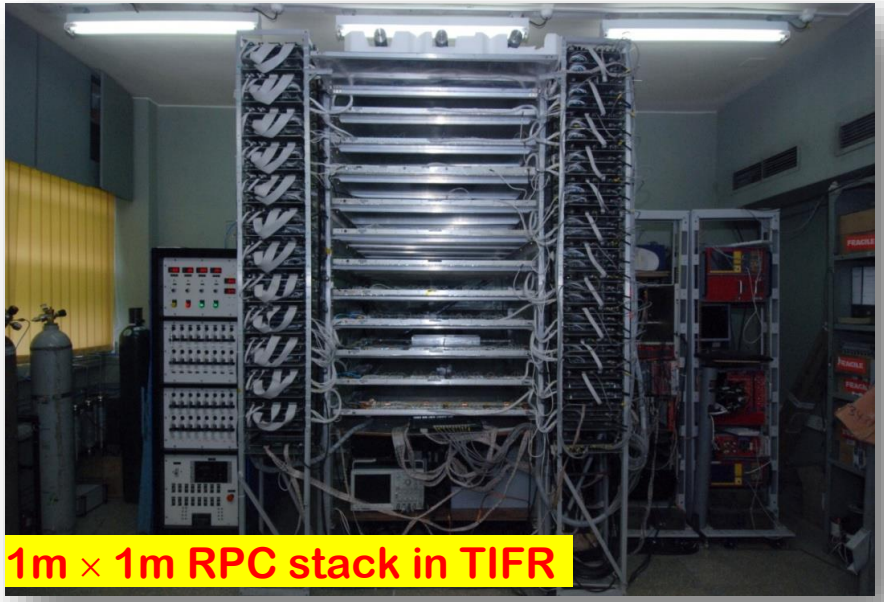
The project includes:

- construction of an underground laboratory and associated surface facilities,
- construction of a Iron Calorimeter (ICAL) detector for neutrinos,
- setting up of Inter-Institutional Centre for High energy Physics (IICHEP).

A successful INO-Industry interface developed because of the large scale of experimental science activity involved.

INO Graduate Training Programme under the umbrella of Homi Bhabha National Institute (HBNI) - is in its eighth year (30 Ph.D. students in Physics, detectors and electronics).

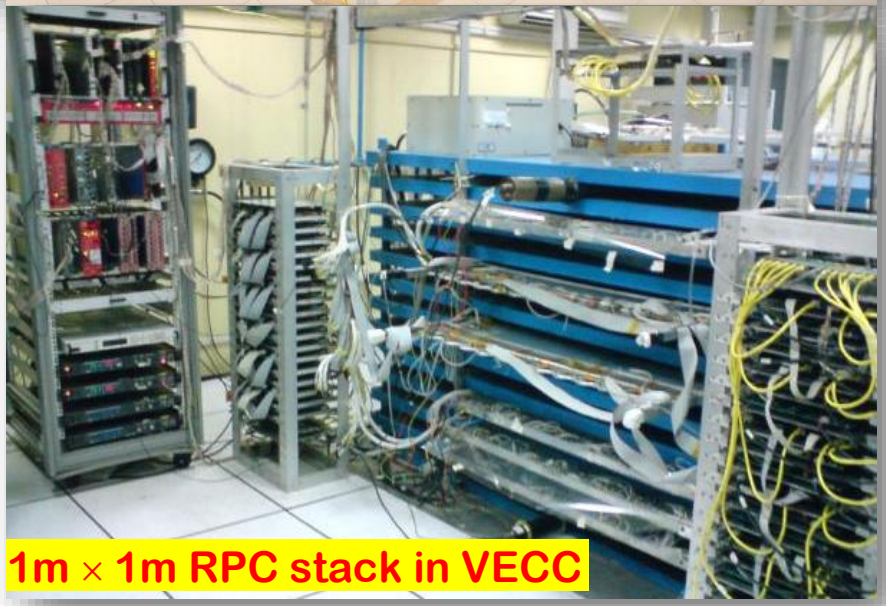
Prototyping of ICAL detector



1m × 1m RPC stack in TIFR

2m × 2m RPC test stand in TIFR

1m × 1m RPC stack in Madurai



1m × 1m RPC stack in VECC

Gravity and Fundamental Interactions

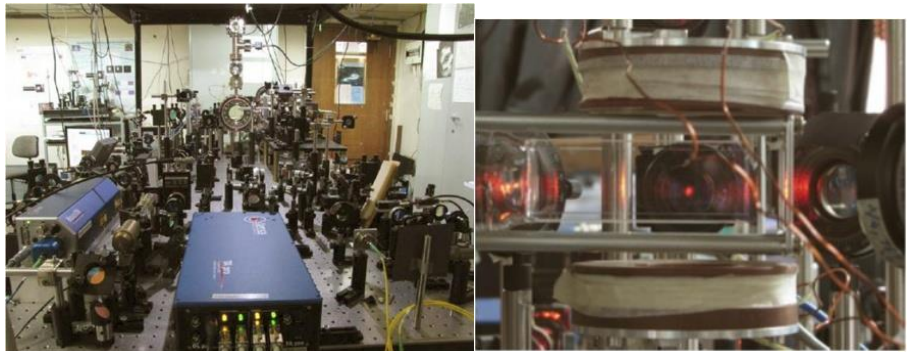
C.S. Unnikrishnan etal.

FOCUS: Experimental and theoretical studies of fundamental aspects of gravity, equivalence principle, relativity, quantum vacuum, and quantum correlations with novel precision measurements employing laser-cooled atoms, optical and matter-wave interferometers and precision mechanical oscillators.

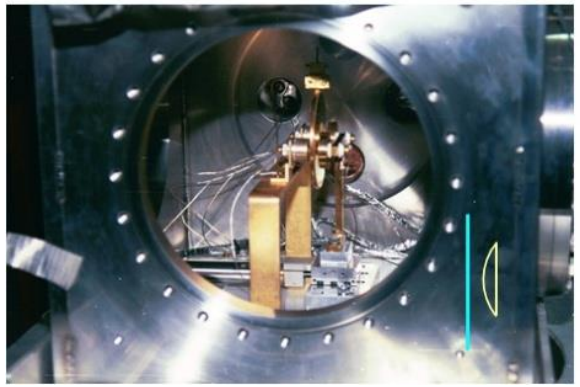
A. Technical Capabilities:

1) Metrology with laser-cooled atoms of different species down to micro-Kelvin temperatures in magnetic and optical traps, and in free-space.

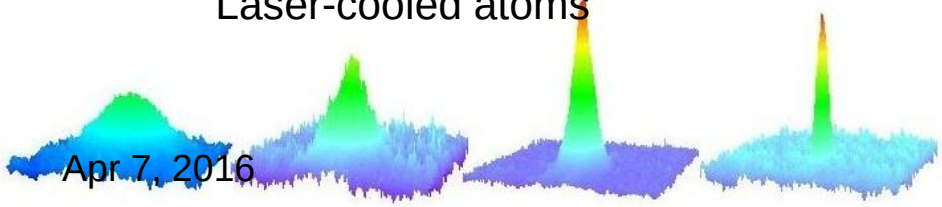
2) Sensors that can measure forces smaller than a femto-Newton, light and matter-waves interferometers that can measure time and space intervals with resolutions below atto-seconds and femto-meters.



Laser-cooled atoms



Torsion balance for short-range force



Bose-Einstein condensate of Rubidium

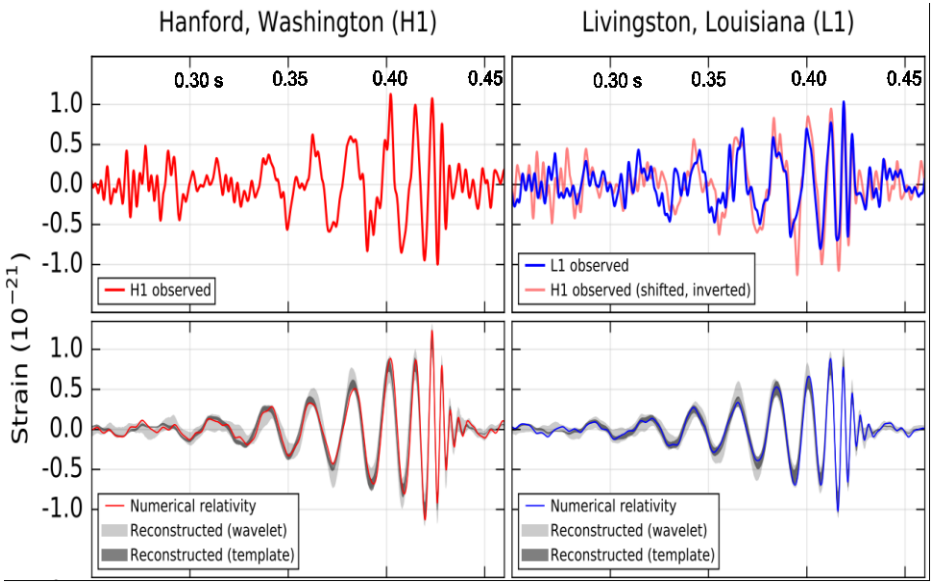
B. “Cosmic Relativity” as a new paradigm for dynamics and relativity, with several associated original experiments:

Velocity dependent gravitational potentials due to all the matter in the universe determine laws of dynamics as well as ALL relativistic phenomena. This has strong empirical support, verified predictions, and agrees with **all** known crucial experiments.

(Advances in Theoretical Physics, (World Scientific, 2008) - Int. Jl. Mod. Phys **30**, 1460267 (2014)). Many experiments and analysis in progress.

C. LIGO-Scientific Collaboration (council member) and LIGO-India (coordinators’ comm.)

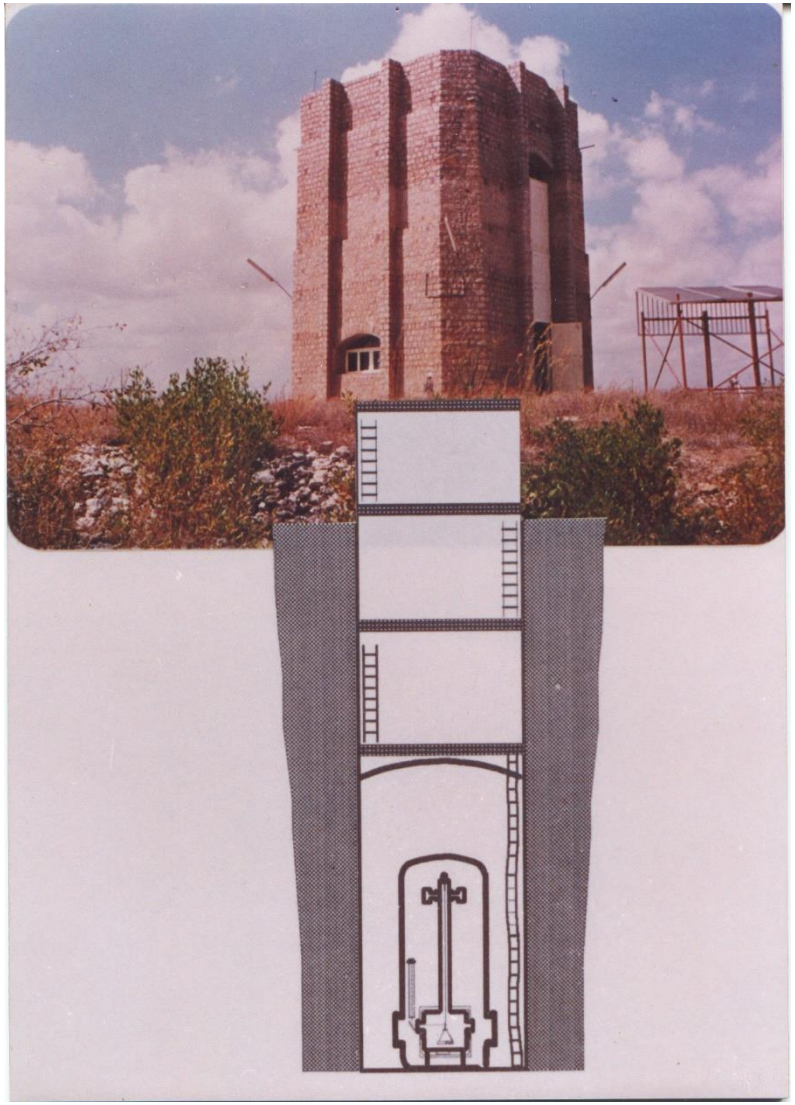
1) Prototype interferometer detector
2) Detection of gravitational waves and binary black holes’ merger
3) Cabinet approval for LIGO-India



Test of the Equivalence Principle

N. Krishnan etal.

Gauribidanur Lab.



The Torsion Balance is the most *natural* instrument to use for sensitive tests of the Equivalence Principle (EP).

Violation of the EP $\Rightarrow$ modulation of torsion balance mean with 24-hour period.

Showing the specially constructed laboratory at Gauribidanur, designed to isolate the delicate torsion balance from gross thermal and micro-seismic disturbance. The torsion balance oscillates serenely, 80 feet underground, protected from Brownian Motion noise, magnetic fluctuations, and barometric pressure variations. It is tuned to respond solely to a violation of the Universality of Free-Fall in the gravitational field of the Sun.

Outlook

- High energy physics deals with big and small things.
- We build precise sophisticated equipment.
- We deal with huge volumes of data
- It all helps us look for tiny particles and takes us back in time

More to come in these two days in the presentations of DHEP members