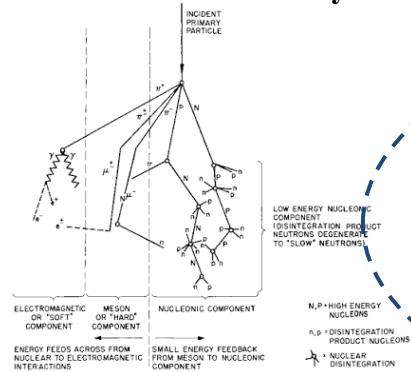


Who are we?

- From the inception of TIFR, DHEP has been the only family member involved in experimental investigations of the fundamental constituents of matter and their interactions

Bhabha-Heitler theory

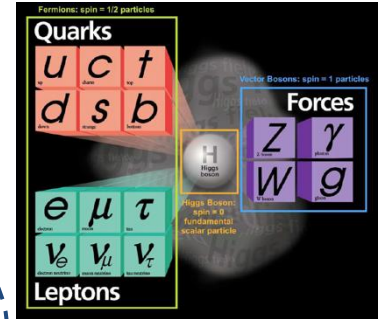


Energy frontier
Higgs, top quark...

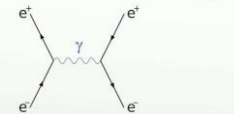
Intensity frontier
Flavor, neutrinos...

Cosmic frontier
Cosmic, γ rays...

Sensitivity frontier
Positronium, FIP...



Bhabha scattering



Facility

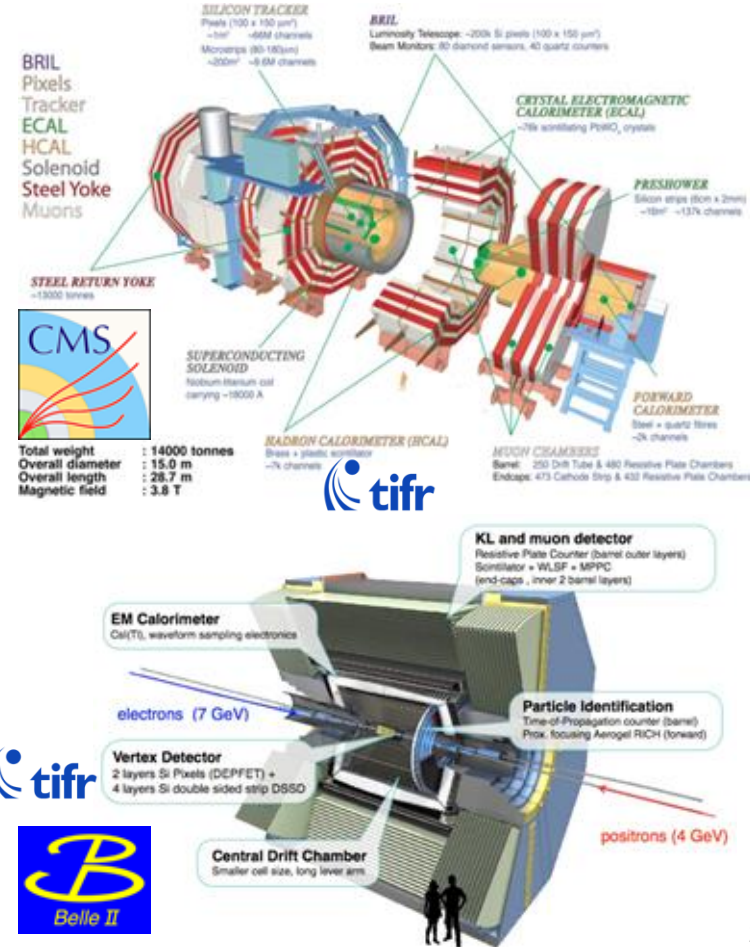
Detector

Computing



Collider Physics (MSV programs)

- Encompasses two key frontiers in HEP:
Energy (CMS at LHC) and **Intensity** (Belle II at SuperKEKB) $\Rightarrow$ **complement each other**
- We are actively engaged in Higgs boson and top quark physics, and BSM searches (CMS), CP violation and rare B decays (Belle II), and detector instrumentation
- Growing demands from HL-LHC, Belle II upgrade, and future collider programs, e.g. FCC necessitate expansion of expertise



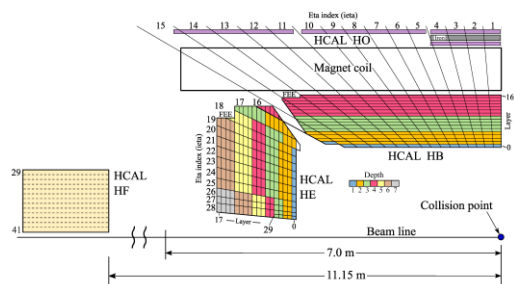
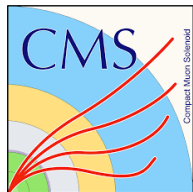
What have we been doing?

Detector building

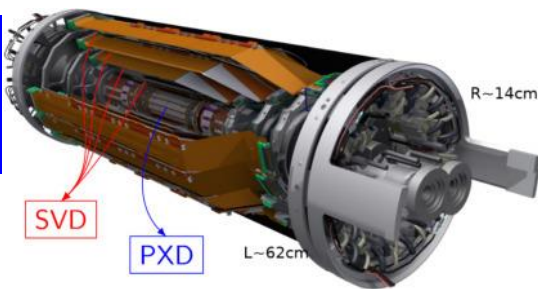
Detector operation

Physics harvesting

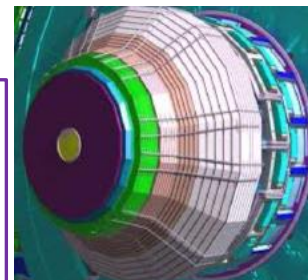
Upgrade



- Support to data collection, detector operation (visit to lab is essential)
- Participation in detector calibration (ECAL & HCAL in CMS and SVD in Belle II)
- Performance of physics objects (electron, photon, jets etc. at CMS, and B-meson tagging at Belle II)

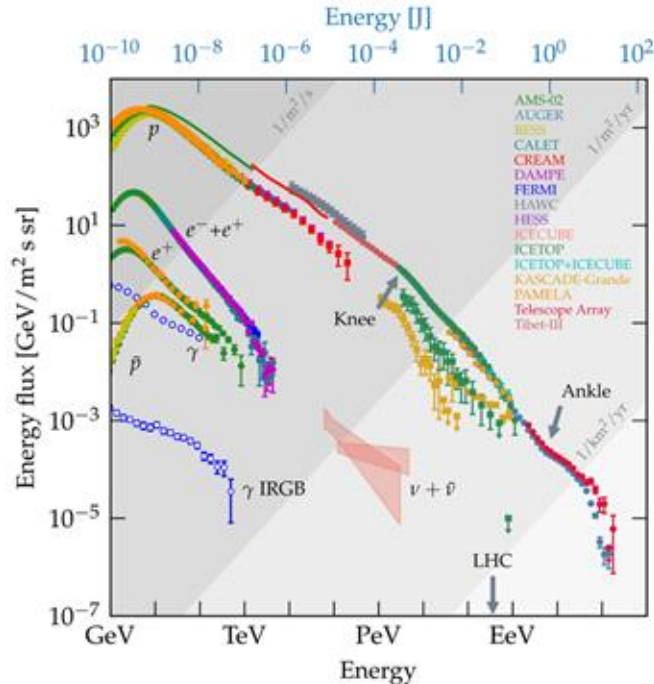


- Thrust area of Higgs boson and top quark physics, in addition to BSM searches and precision tests of the SM
- CP violation in rare decays (litmus test of the SM) and rare decays of B and D mesons as indirect probes of the SM



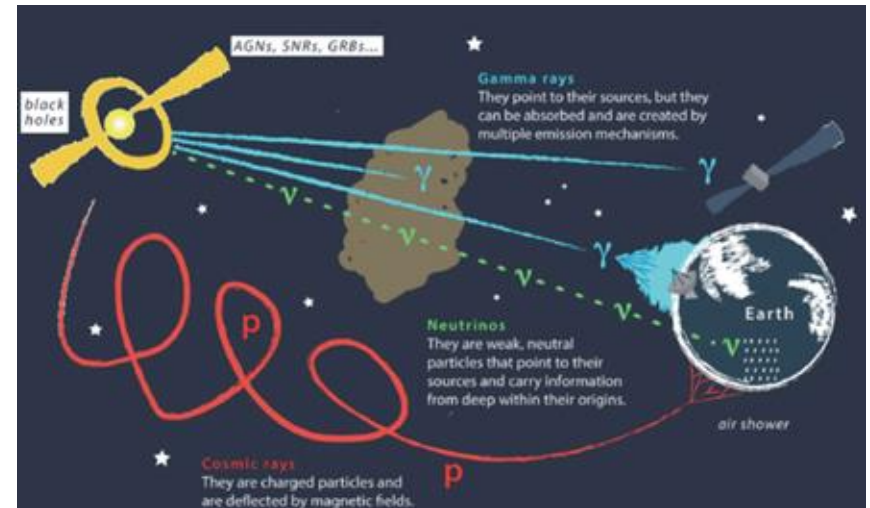
- Upgrade of trigger and novel high granularity calorimeter)
- Interest in the upgrade of vertex detector systems

Astroparticle Physics: ν , γ and cosmic rays



- A proper understanding of most extreme environments in universe (black hole jets, neutron stars, supernova explosions) calls for a **multi-messenger view**
- DHEP activities in all three areas share commonalities in detection technology, shower generations, event classifications

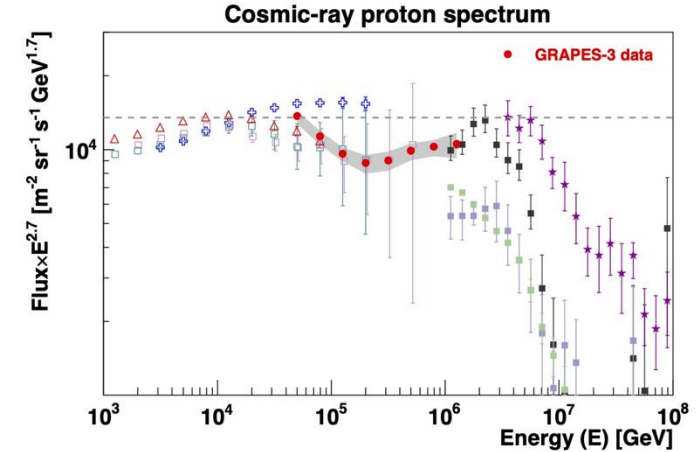
- Origin and composition of cosmic rays
 - Where do they come from?
 - What are they made of?
- Spectral features
 - What do the features in the spectrum signify?
- Acceleration and propagation
 - How are they accelerated to such high energy?
 - How do they influence their environment?



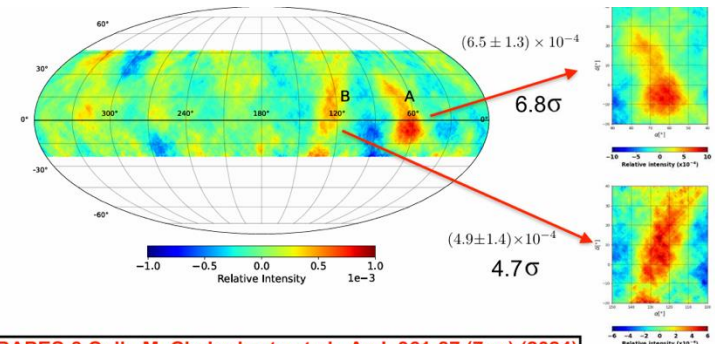
GRAPES-3: Science Goals and Recent Results

- Due to its unique design and geographical advantage, GRAPES-3 is playing a key role in providing accurate measurements in the knee region ($10^4 - 10^7$ GeV) to address the open problems of sources, acceleration and propagation of galactic cosmic rays
- It uses tools such as measurement of cosmic ray energy spectrum, mass composition, anisotropy, and PeV gamma sources
- Additionally, GRAPES-3 detectors have huge potential for probing heliospheric and space weather physics

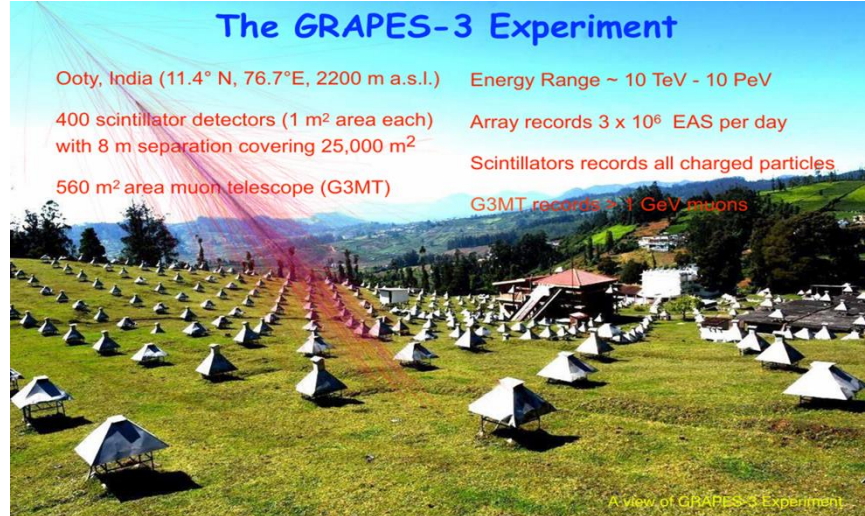
GRAPES-3 Coll., F. Varsi et al., PRL 2024



Cosmic ray Anisotropy

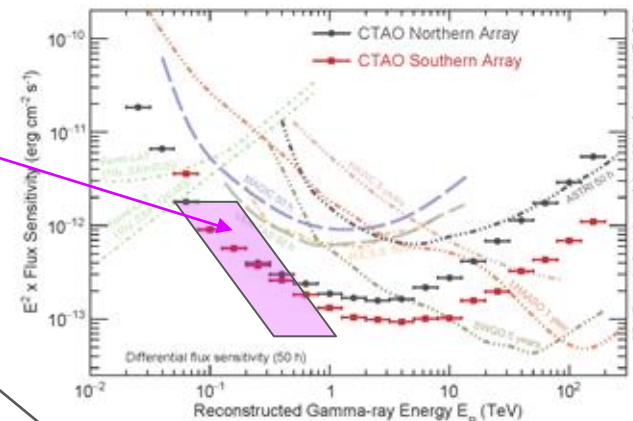


GRAPES-3 Coll., M. Chakraborty et al., ApJ, 961:87 (7pp) (2024)



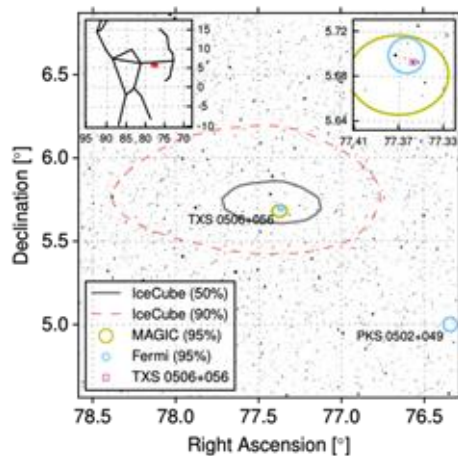
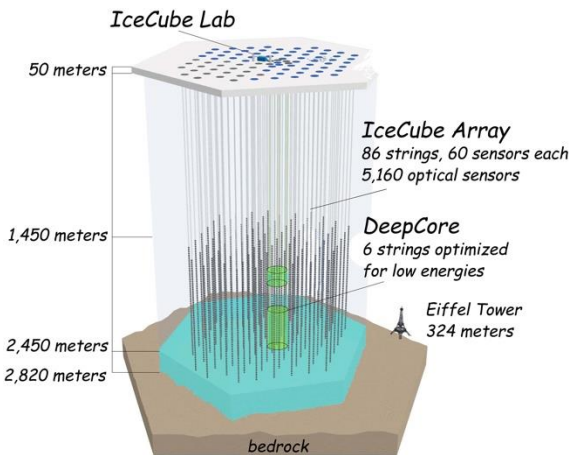
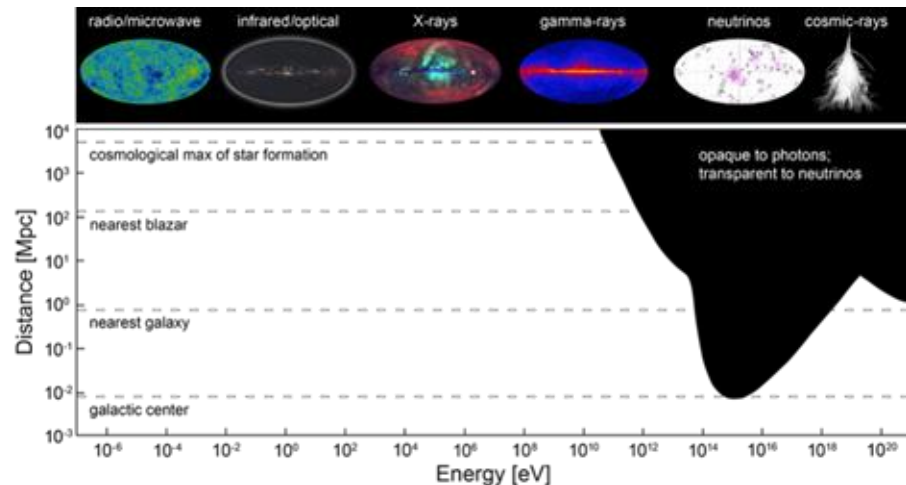
High Energy Gamma-Ray Astronomy

- History:
 - TIFR has rich legacy starting from PACT (Pachmarhi) and HAGAR (Hanle) until now
- Rapidly evolving field, national and international
 - MACE telescope at Hanle, Ladakh already operational
 - MACE stereo has been proposed:
 - Competitive sensitivity at ~100s GeV
 - An SiPM-based imaging camera developed in-house is currently under commissioning at Mt. Abu
 - State-of-the-art technology with Si devices, fast readout, and complex trigger mechanisms
 - Improved duty cycle, efficiency, and low power consumption
 - CTAO (collaboration of 32 countries)
 - ~10 sensitivity improvement, ~1000s of new sources
- Need expertise in instrumentation, analysis and simulations (detector calibration) and data interpretation and modelling to optimize the science results



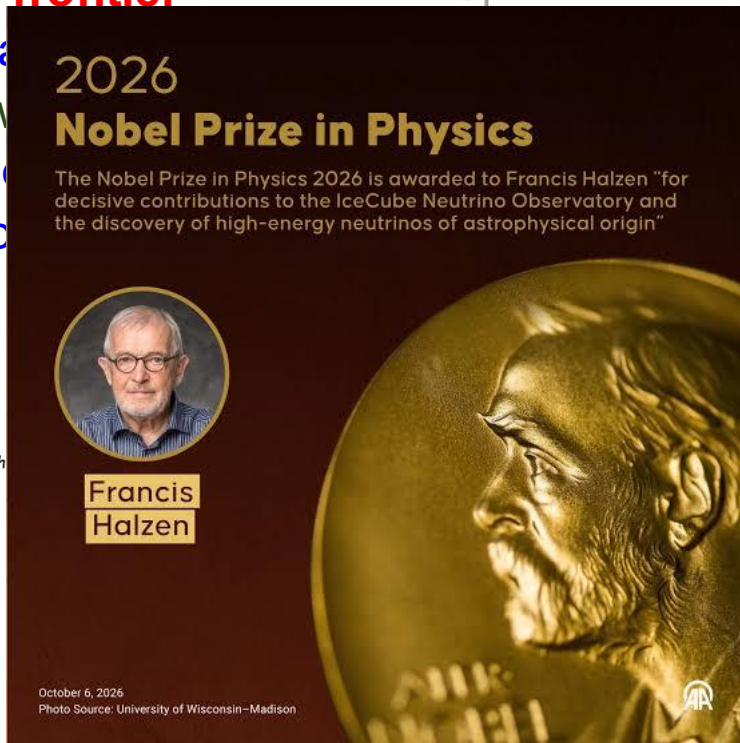
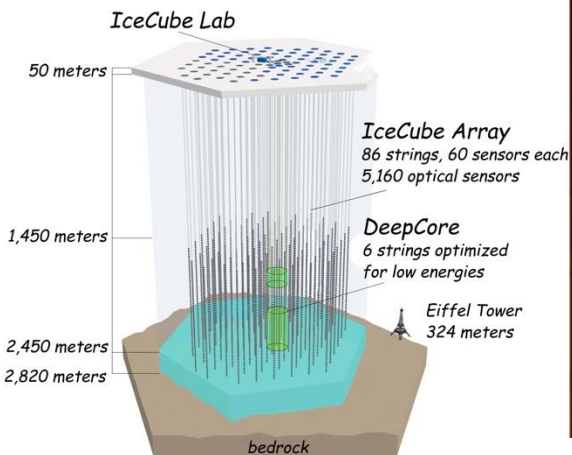
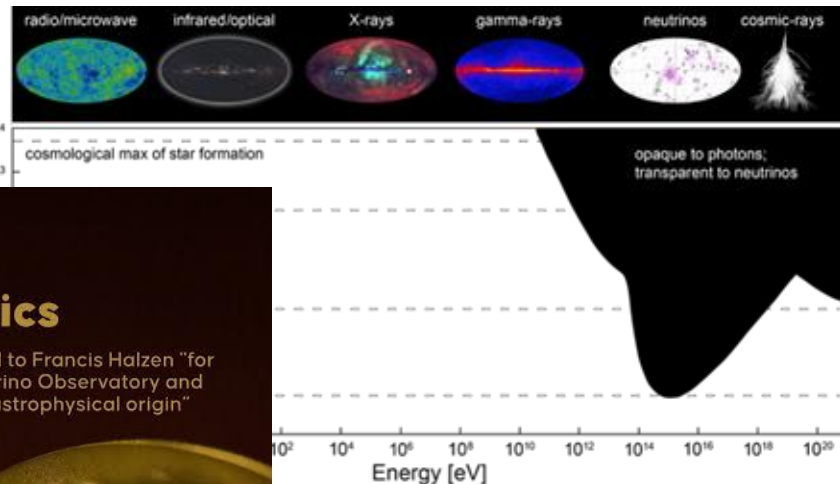
Neutrino Astronomy

- The birth of neutrino astronomy with **IceCube** make neutrinos an important pillar of the **Cosmic frontier**
- We are actively engaged in design of IceCube-Gen2 (software front)
- Works underway to explore possible hardware contribution



Neutrino Astronomy

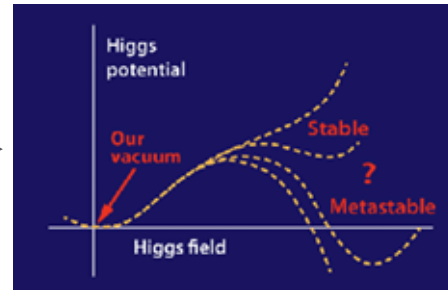
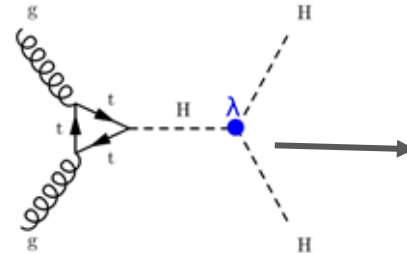
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Future Goals and Opportunities

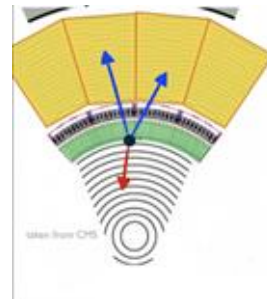
Physics:

- Precision measurements of the top quark and Higgs boson, especially study of Higgs self-coupling
- Probing new sources for CP violation and super-rare decays of beauty and charm mesons
- Search for the dark sector and unconventional signatures



Detector/Instrumentation:

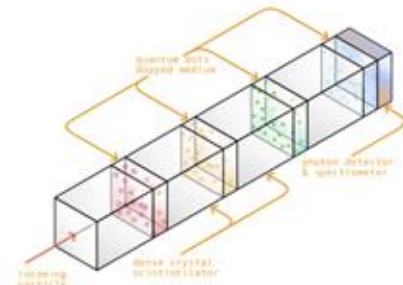
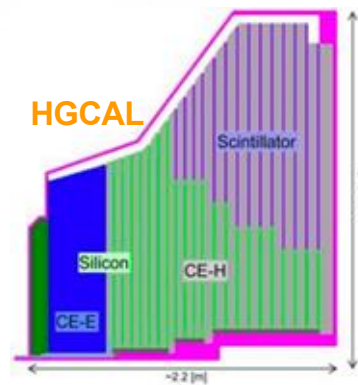
- Develop next-generation silicon-based detectors, such as High Granularity Calorimeter (HGCAL)
- Fast-timing calorimeters and quantum sensor R&D
- Scalable DAQ and trigger for future collider expts



Tag backward moving particles with better timing detectors

Improvement in various fronts using ML:

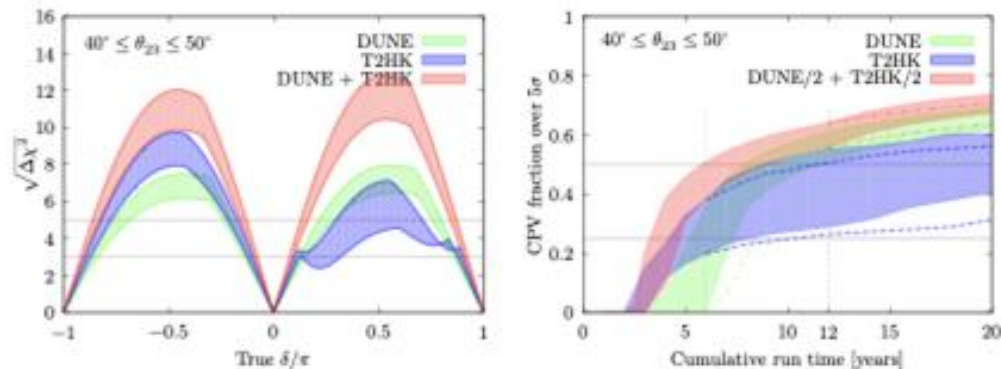
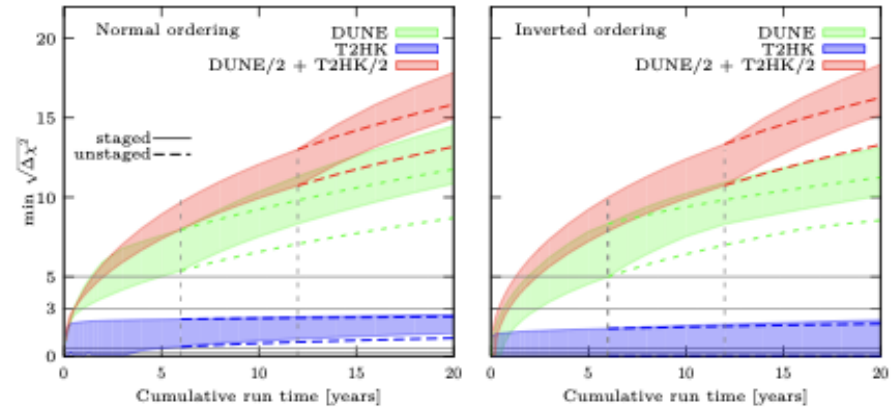
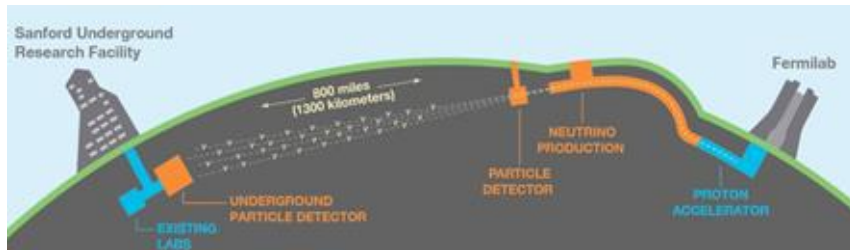
- Use of Generative models to learn the distributions in data
- Physics aware networks to improve sensitivity of several BSM searches e.g. long-lived particles
- Large Language Models to improve the detector reconstruction



Color calorimetry with quantum dots

Neutrino Oscillation Physics

- Neutrino oscillations (consequently, nonzero neutrino masses) are the 1st **definitive** signature of **BSM physics**
- CP violation in neutrino sector and neutrino mass ordering will be two key questions that DUNE and HyperK will address over the next two decades
- On the lookout for faculty candidates who are expert in this area



Exploring a simple system



Positronium : Scientific Scope

Medical Imaging
(PET R&D phase)

Quantum Technologies

Ps₂ molecules and BEC
studies

Development of Compton telescope
for astronomy, nuclear emission
detection, etc. (applications from
defense to oil & gas industries)



Fundamental Physics

Precision QED tests

CPT and Lorentz violation tests

New physics searches

Material Science (PALS)

Welcome to CRL, Ooty

25 March 2026

1. Name of the Event: Annual Meeting of the Department of High Energy Physics

2. Date and venue of the event: Oct 15-16, 2026, Cosmic Ray Laboratory, TIFR, Ooty.

3. Topical interest of the event: The annual meeting of the Department of High Energy Physics has been held in Mumbai. However, given that GRAPES-3 is a major experimental facility of the department, it is proposed to organize this meeting at the Cosmic Ray Laboratory in Ooty to provide participants with direct exposure to this world-class facility. Hosting the event at this location will enable participants to gain first-hand insight into the experimental infrastructure and ongoing research activities. It will also promote meaningful interactions between the staff based in Ooty and members from Mumbai, thereby fostering the exchange of technical ideas, expertise, and knowledge, and strengthening collaboration within the department.

4. Organizing Committee (Alphabetical order)

Rajadeep M. Chatterjee, P. Jagadeesan, Shilpi Jain, Atul Jain, Gobinda Majumder, Gagan B. Mohanty, Pravata K. Mohanty, Mohamed Rameez, Atreyee Sinha

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4. Organizing Committee (Alphabetical order) **Organizing committee for the DHEP Annual Meeting**

Rajadeep M. Chatterjee, P. Jagadeesan, Shilpi Jain
Pravata K. Mohanty, Mohamed Rameez, Atul Jain

Gagan Mohanty <gmohanty@tifr.res.in>

Mon, Sep 7, 2026 at 6:26 PM

To: Pravata Mohanty <pkm@tifr.res.in>, Pravata Mohanty <pravata2006@gmail.com>, Shilpi Jain <shipsjains@gmail.com>, Bharat Singh <bbsingh@tifr.res.in>, Atul Jain <ajain@tifr.res.in>, P Jagadeesan <jagadeesan@tifr.res.in>, B Hari Haran <89hariharan@gmail.com>

Dear colleagues,

As you know, the next DHEP Annual Meeting will be held at CRL, Ooty **during October 15-16, 2026 (Thursday and Friday)**. On behalf of the department, I am requesting you to help us in the organization of this important event. Pravata may please convene the organizing committee.

Thanks and regards,
Gagan