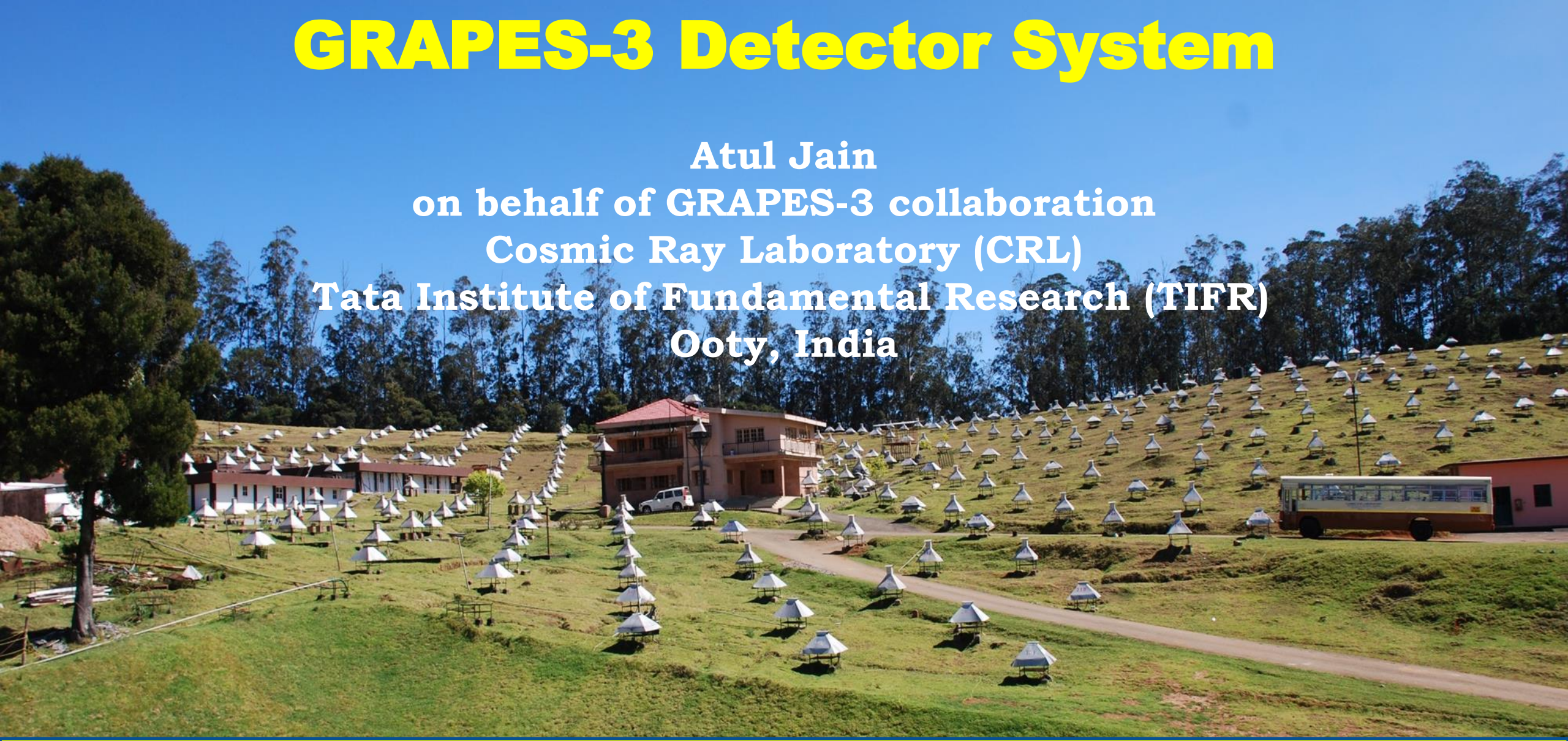
GRAPES-3 Detector System

Atul Jain
on behalf of GRAPES-3 collaboration
Cosmic Ray Laboratory (CRL)
Tata Institute of Fundamental Research (TIFR)
Ooty, India



21 FEB 2019 15th Vienna Conference on Instrumentation

Current status of GRAPES-3

(Gamma Ray Astronomy at Pev EnergieS

(An India-Japan collaboration)

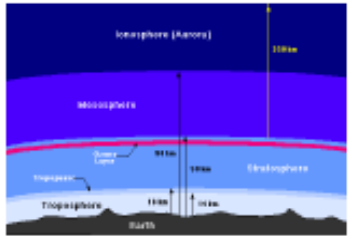
S.K. Gupta, H.M. Antia, S.R. Dugad, I. Mazumdar, P.K. Mohanty, P.K. Nayak, P. Jagadeesan, A. Jain, S.D. Morris, B.S. Rao, Y. Hayashi, S. Kawakami, S. Ogio, H. Kojima, R. Koul, V.K. Dhar, K. Venugopal, S. Das, S.K. Ghosh, S, Raha, P. Joarder, P. Subramanian, P. Jain, A. Oshima, H. Tanaka, S. Shibata, U.D. Goswami, S. Ahmad Badruddin, R. Hasan, A. Bhadra, R.K. Dey, S.K. Sarkar, C.S. Garde

1. Tata Institute of Fundamental Research, Mumbai, India
2. Osaka City University, Osaka, Japan
3. Aichi Institute of Technology, Toyota, Japan
4. Bhabha Atomic Research Centre, Mumbai, India
5. J.C. Bose Institute, Kolkata, India
6. Indian Institute of Science and Engineering Research, Pune, India
7. Indian Institute of Technology, Kanpur, India
8. National Astronomical Observatory of Japan, Tokyo, Japan
9. IPMU, University of Tokyo, Tokyo, Japan
10. Chubu University, Kasugai, Japan
11. University of Dibrugarh, Dibrugarh, India
12. Aligarh Muslim University, Aligarh, India
13. North Bengal University, Siliguri, India
14. Vishwakarma Institute of Information Technology, Pune, India

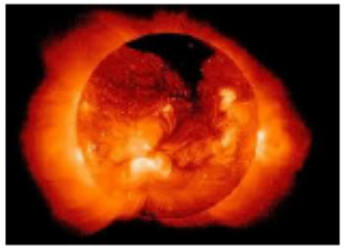
Objective: Universe at high energies

Acceleration, propagation of high energy particles,
Extreme conditions may require new physics ...

1. Acceleration in atmospheric electric field
   Energy ~100 MeV



2. Solar flares, Coronal Mass Ejections
   Energy ~10 GeV



3. Galactic Cosmic Rays at " Knee "
   Energy ~1 PeV

4. Diffuse multi-TeV γ-rays
   Energy ~100 EeV

All of the above science requires the following

- ✓High performance detectors
- ✓ High speed signal processing
- ✓Large data acquisation systems (DAQ)

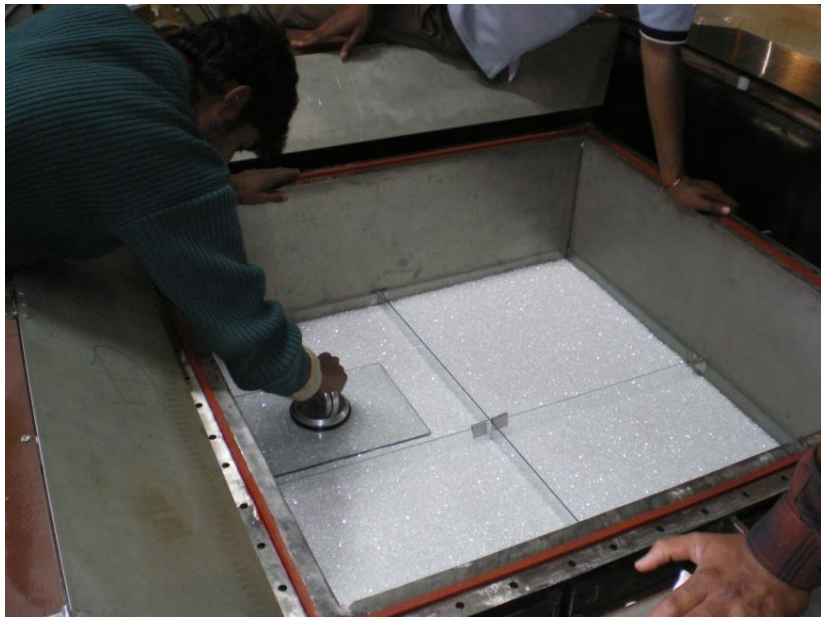
- ❑ Commercial equipment is expensive and does not always meet our exacting requirements
- ❑ Indigenous development of detectors and electronics has become a necessity for us

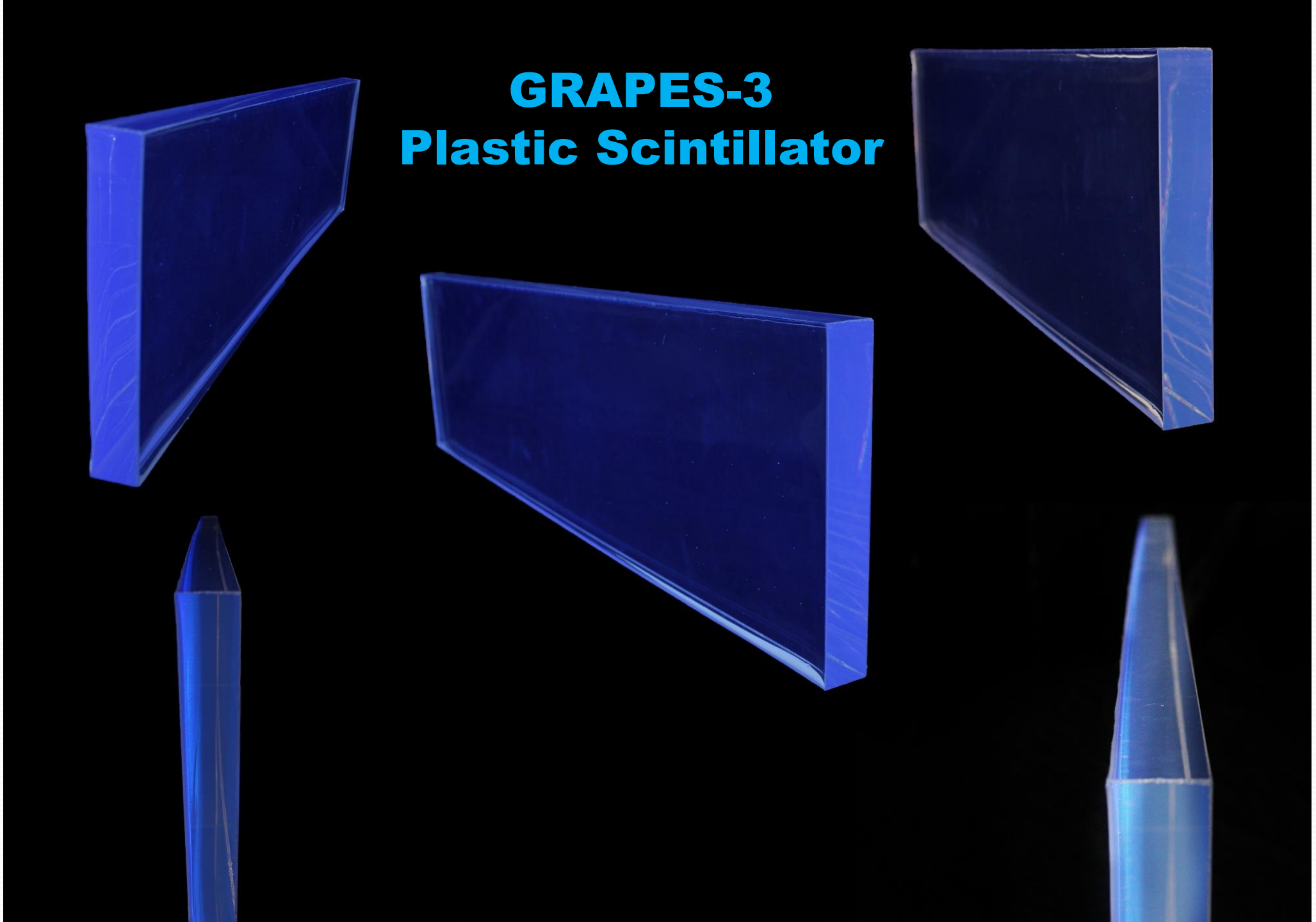
✓ High performance detectors

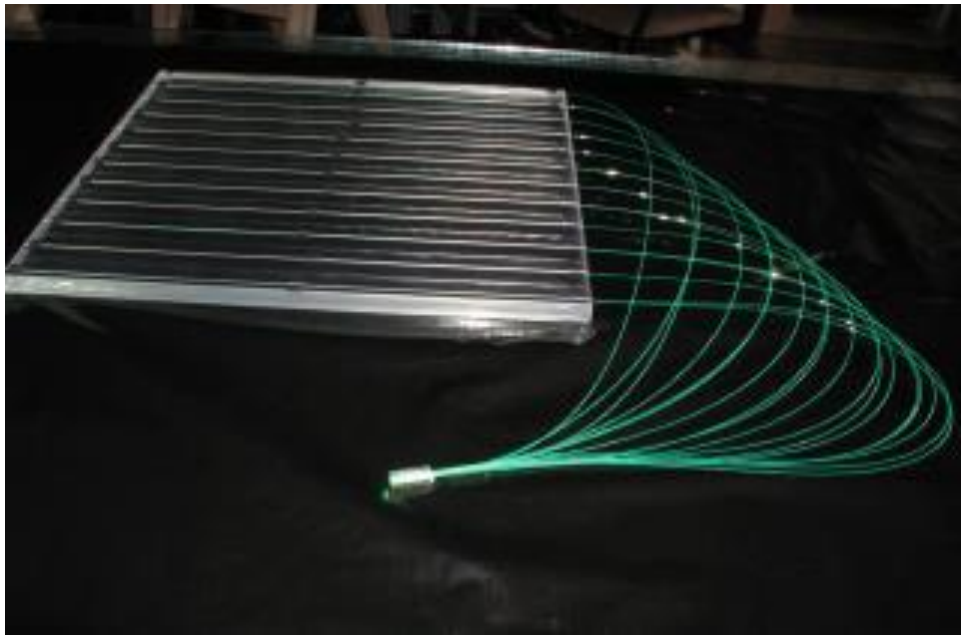
Indigenously developed Plastic Scintillation Detectors

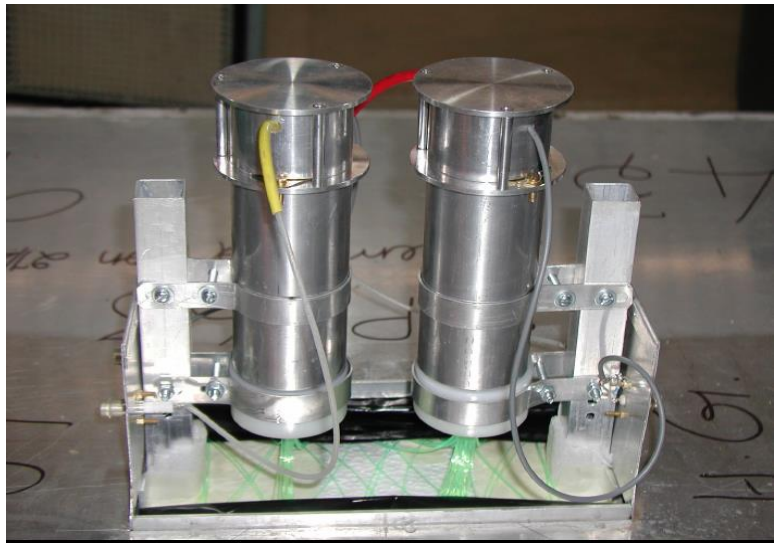
Indigenously developed Proportional Counters

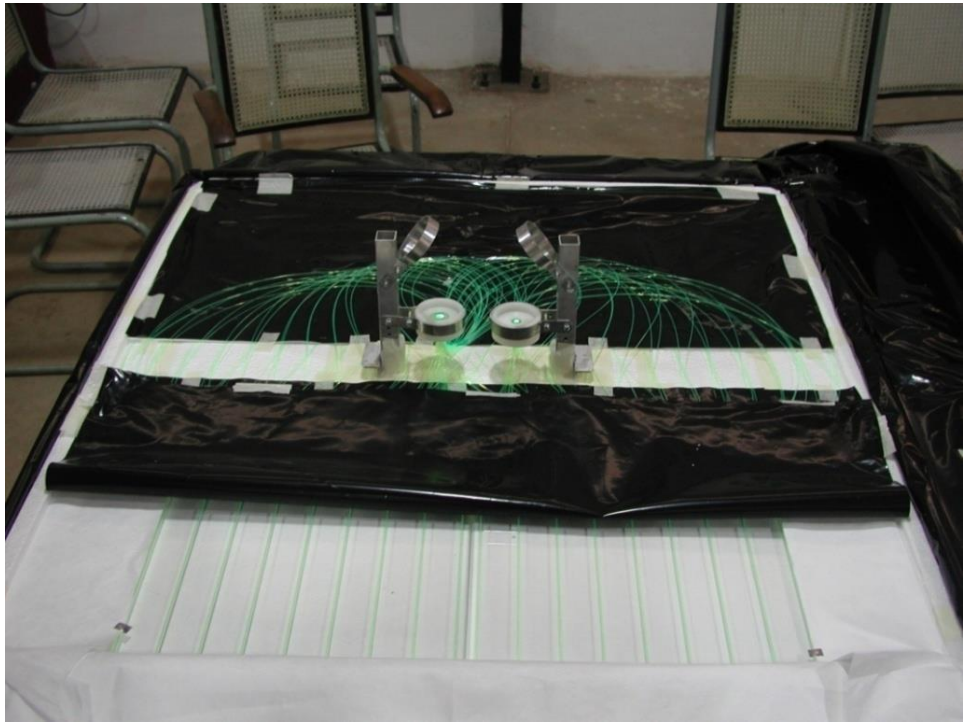
Plastic Scintillator Casting @ GRAPES-3 Ooty

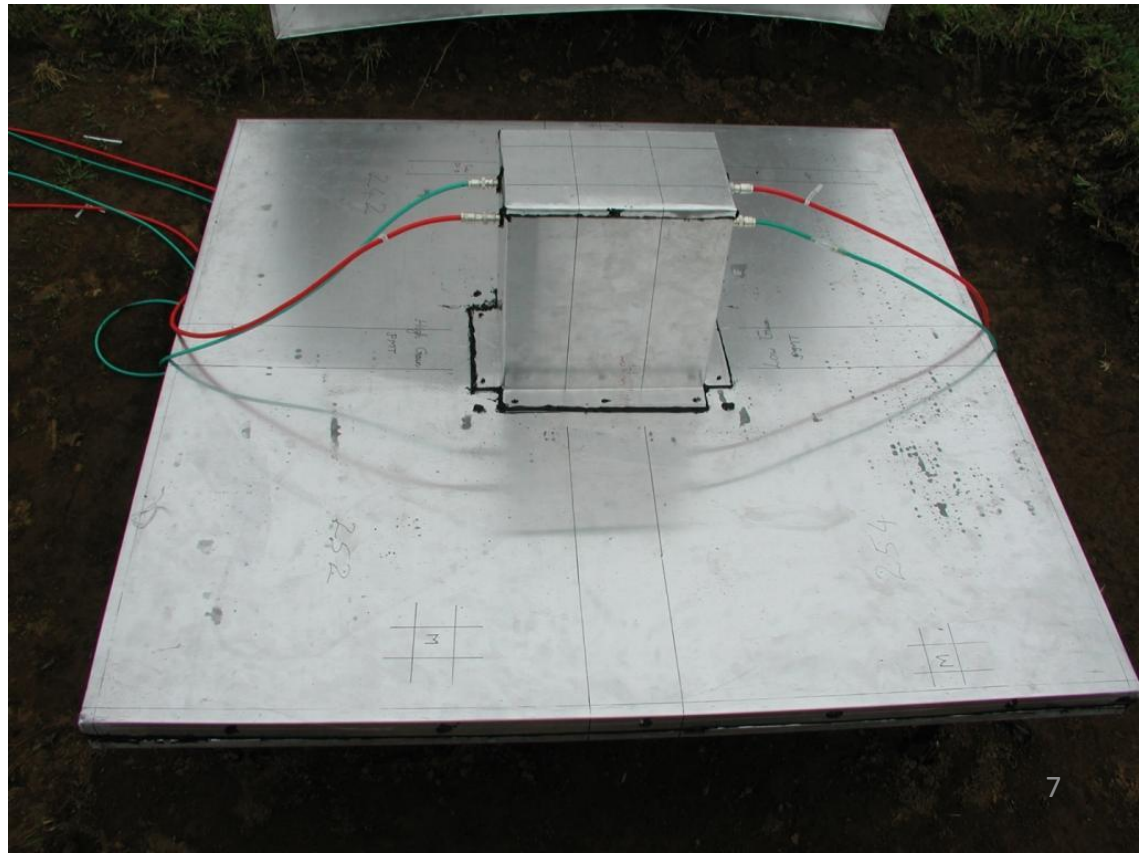



GRAPES-3
Plastic Scintillator







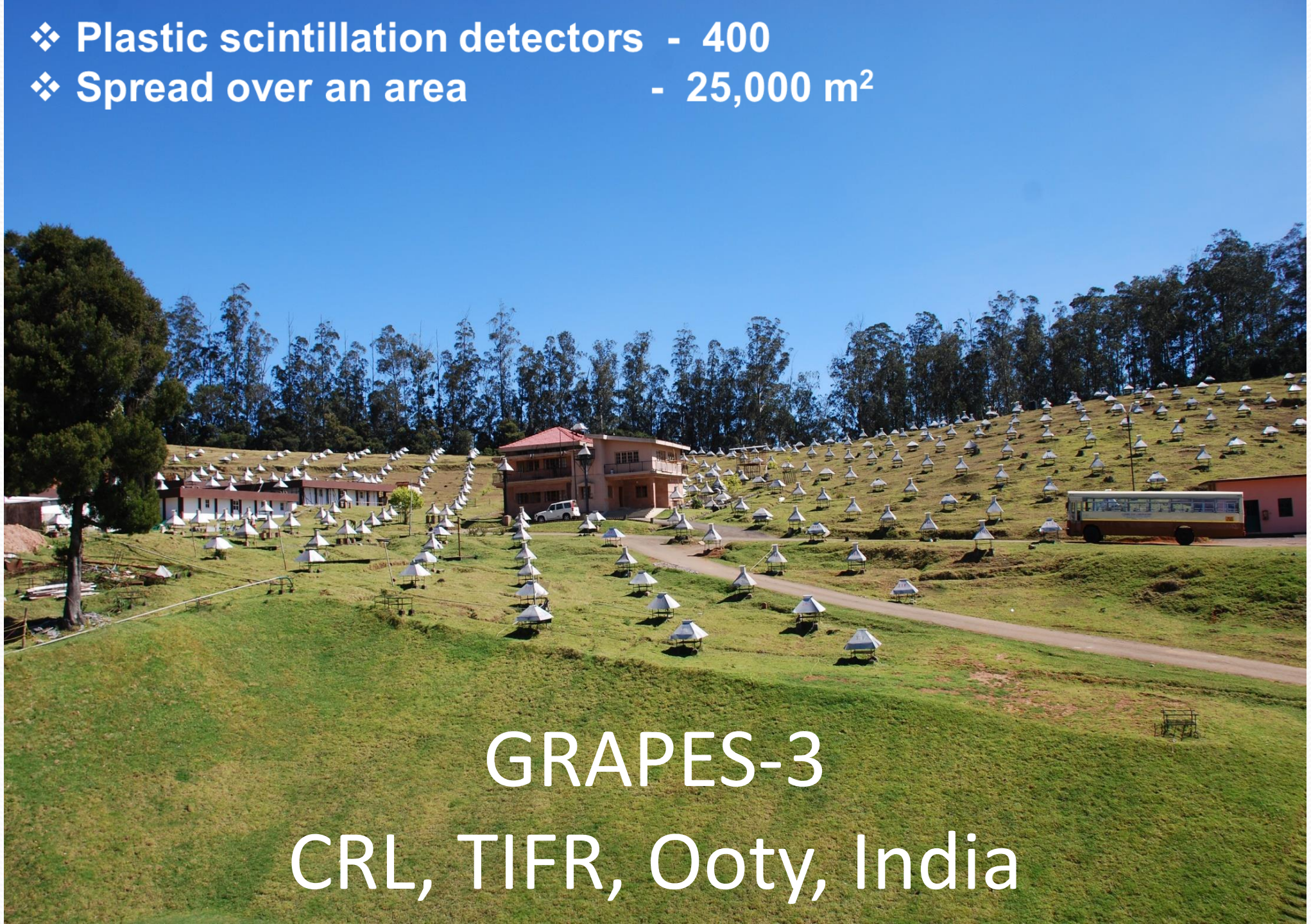


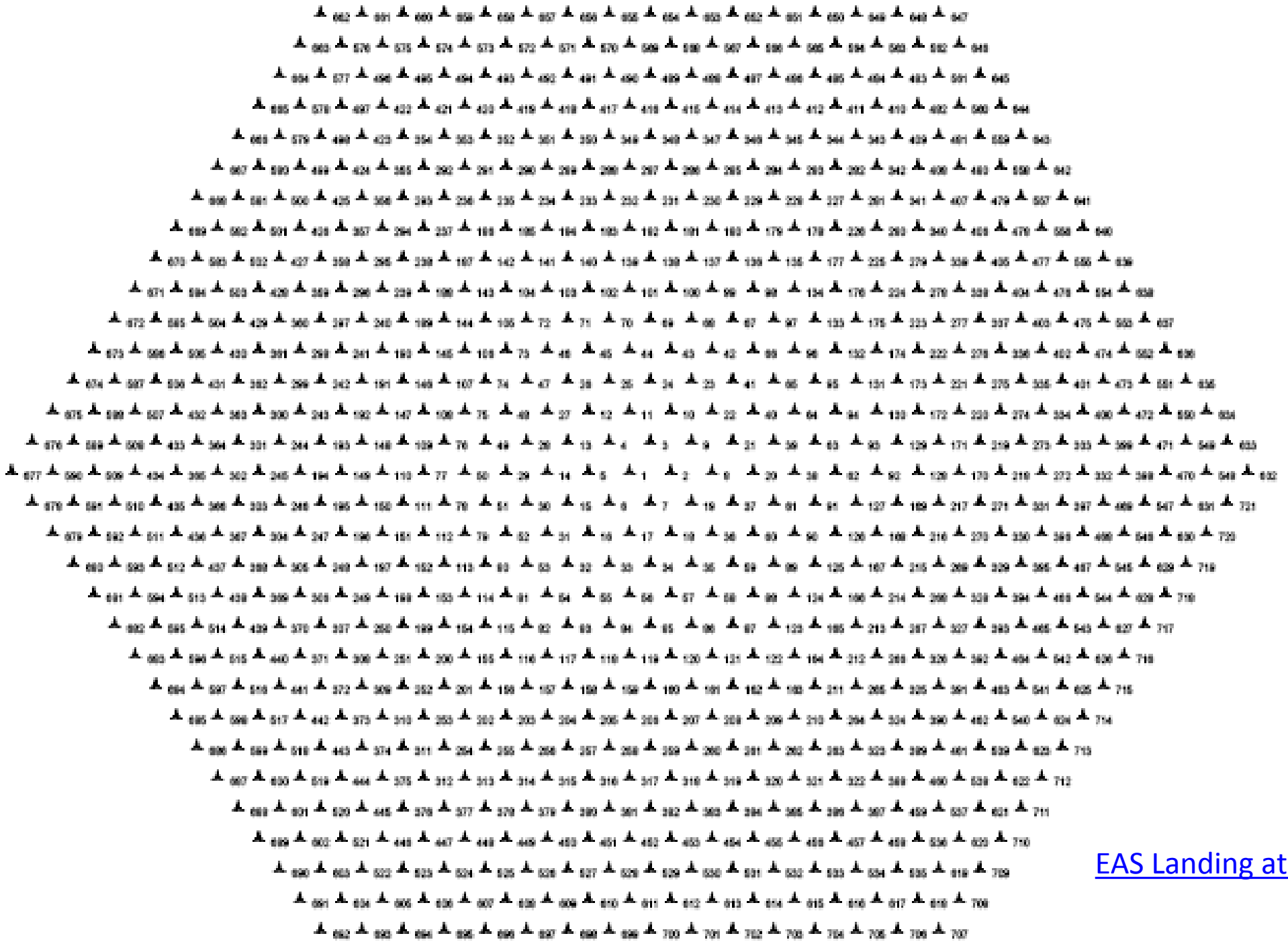
GRAPES-3 Plastic Scintillator

- These state-of-the-art scintillators have a high photon output (55% of anthracene)
- Long attenuation length (>100 cm)
- Short decay time (1.5 nanosecond)

- With the aid of wavelength shifter (WLS) fibre readout, the GRAPES-3 scintillator detector provides a uniform response (r.m.s. non-uniformity <2.5% over $1m^2$ area)
- Large signal from minimum ionizing particles (18 photo-electrons)
- Large dynamic range (1-500 particles with single-PMT, >10000 particles with dual-PMT readout) P.K. Mohanty et al. Astropart. Phys. 31 24 (2009)

- In addition, a Monte Carlo code G3sim developed by the GRAPES-3 team allows precision simulation of the response of assembled scintillator detector with WLS readout
  P.K. Mohanty et al. Rev. Sci. Instrum. 83, 043301 (2012)
- G3sim was used to optimize the design of 200 new scintillator detectors used during expansion of the GRAPES-3 experiment as well as to design detectors for other collaborating institutions


❖ Plastic scintillation detectors - 400
❖ Spread over an area - 25,000 m²
GRAPES-3
CRL, TIFR, Ooty, India



[EAS Landing at GRAPES-3]


GRAPES-3
Experiment of Cosmic...
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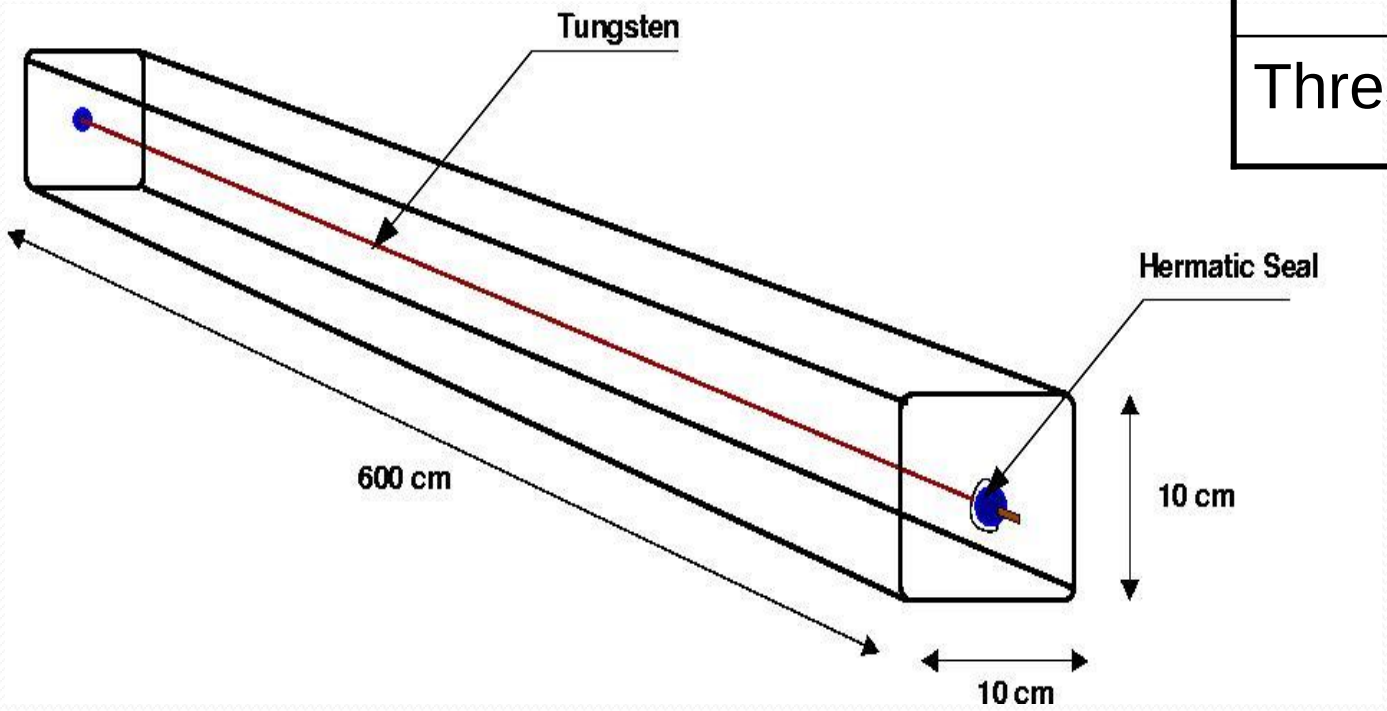
India
3D Earth view is not available
Terms

Proportional Counter

Gas Mixture	90% Ar +10% CH_4
Total	3712
Total Area	560 m^2
Absorber	2.4 m
Threshold	$E\mu$ = 1 GeV



Inside view of Muon Supermodule at GRAPES-3

- Proportional Counter - 3712 nos
- Total area - 560 m^2

Expansion of Muon Detectors

- Double the area of Muon Detectors

$560m^2$ → $1130m^2$

3712nos → +3776 = 7488nos

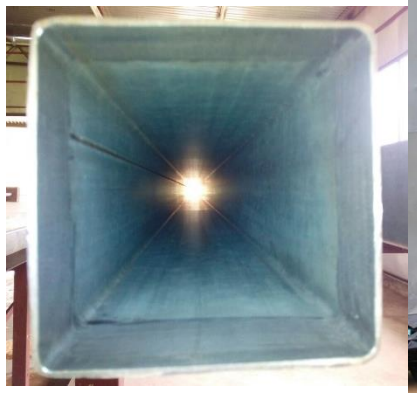
❖ Fabrication and Installation of PRCs

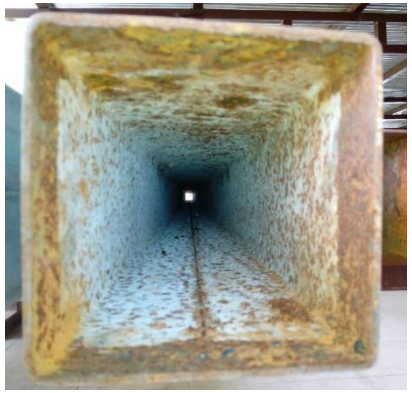
- ❖ Target – 3776 nos

Status as on 14 Feb 2019

- ❖ Fabrication - 3803 nos
- ❖ Installed in Field - 3009 nos
- ❖ Final Test Bench - 645 nos
- ❖ Ready for Final Test - 149 nos

PRC Cleaning





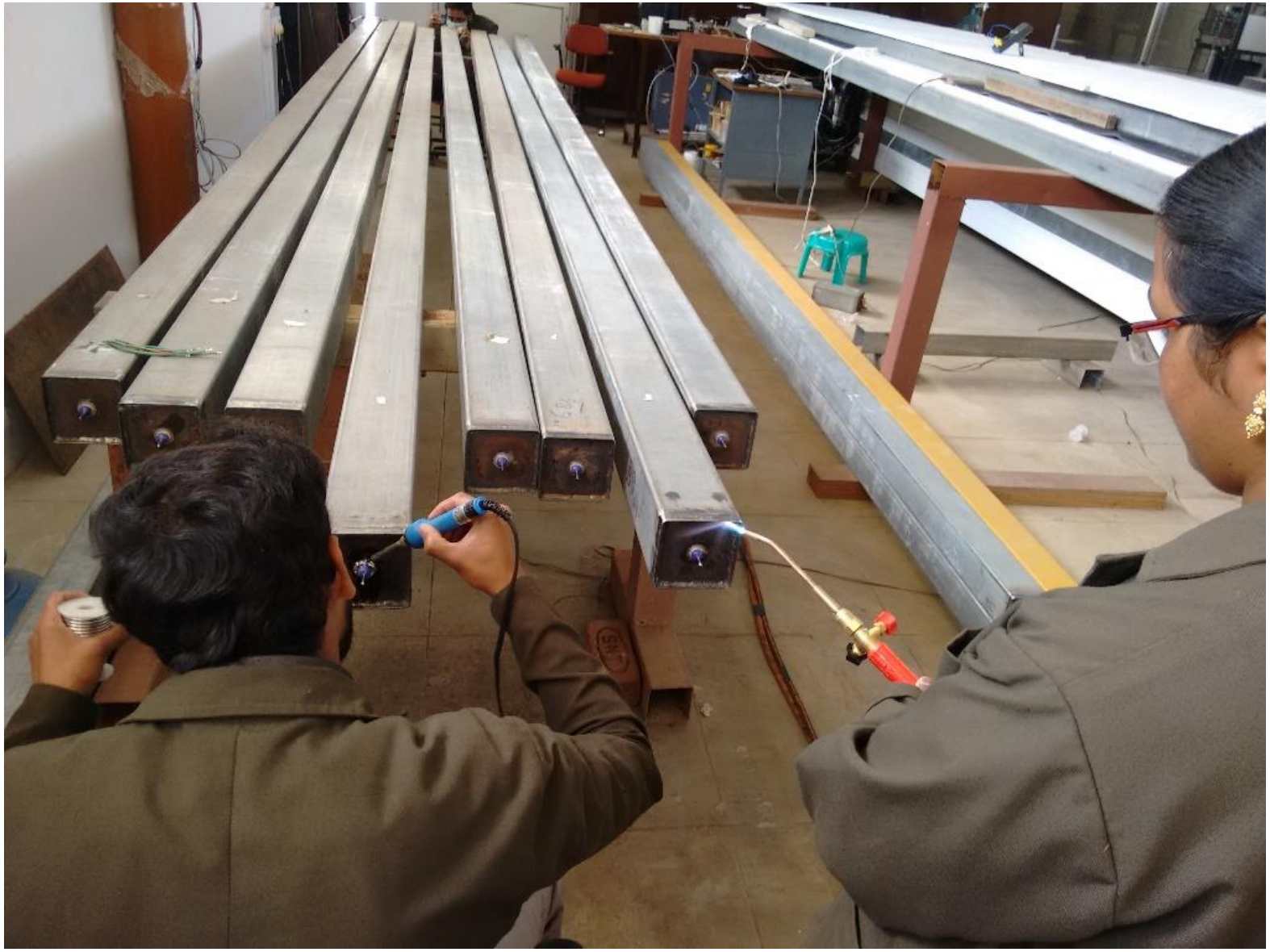
PRC end plate welding

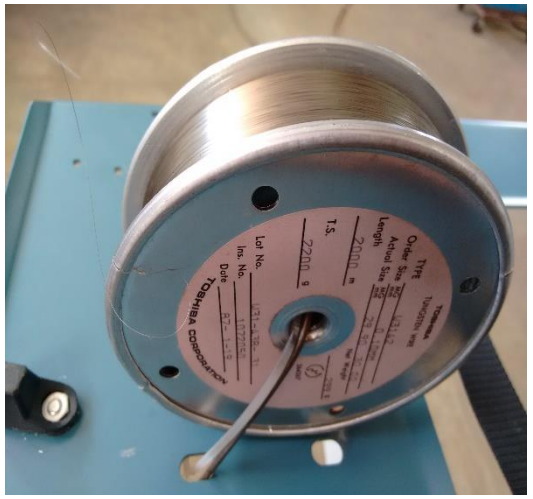
Needle valve assembly and brazing

Needle valve

Counter fixed with needle valve

Tungsten wire assembly & hermetic seal fixing





Tungsten wire

Hermetic seal

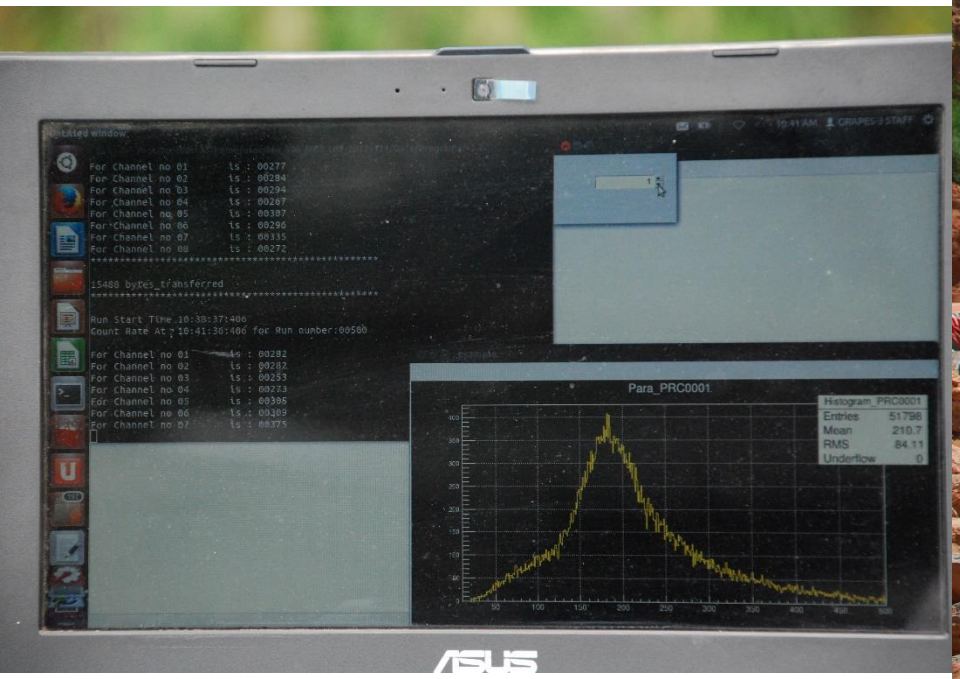
Leak detection, evacuation and gas filling


Evacuation set-1
Evacuation set-2
P10 Gas filling


First Layer
PRCs Placed
March-2016
4
1
2
3
5
8
6
7

Placement of PRCs in the field

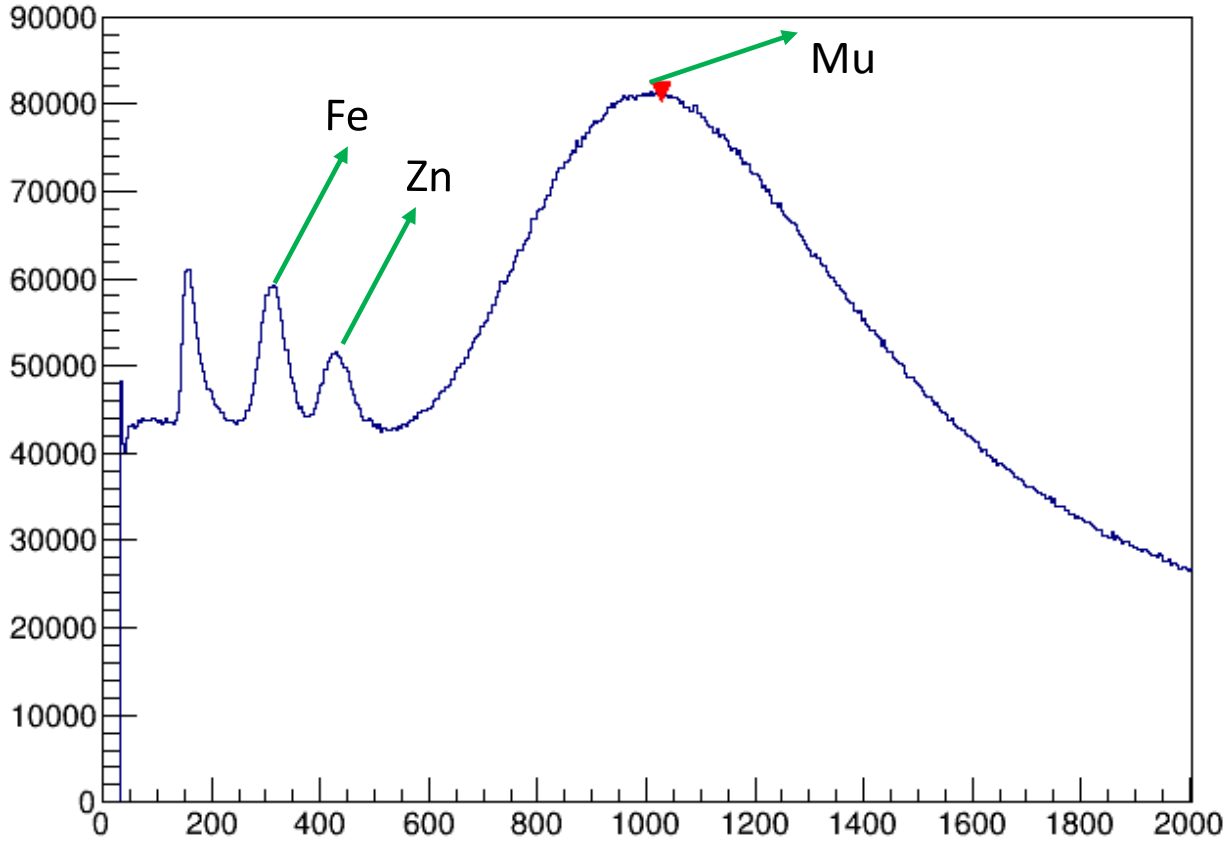
PRC Mobile Test Bench




L4
L3
L2
L1

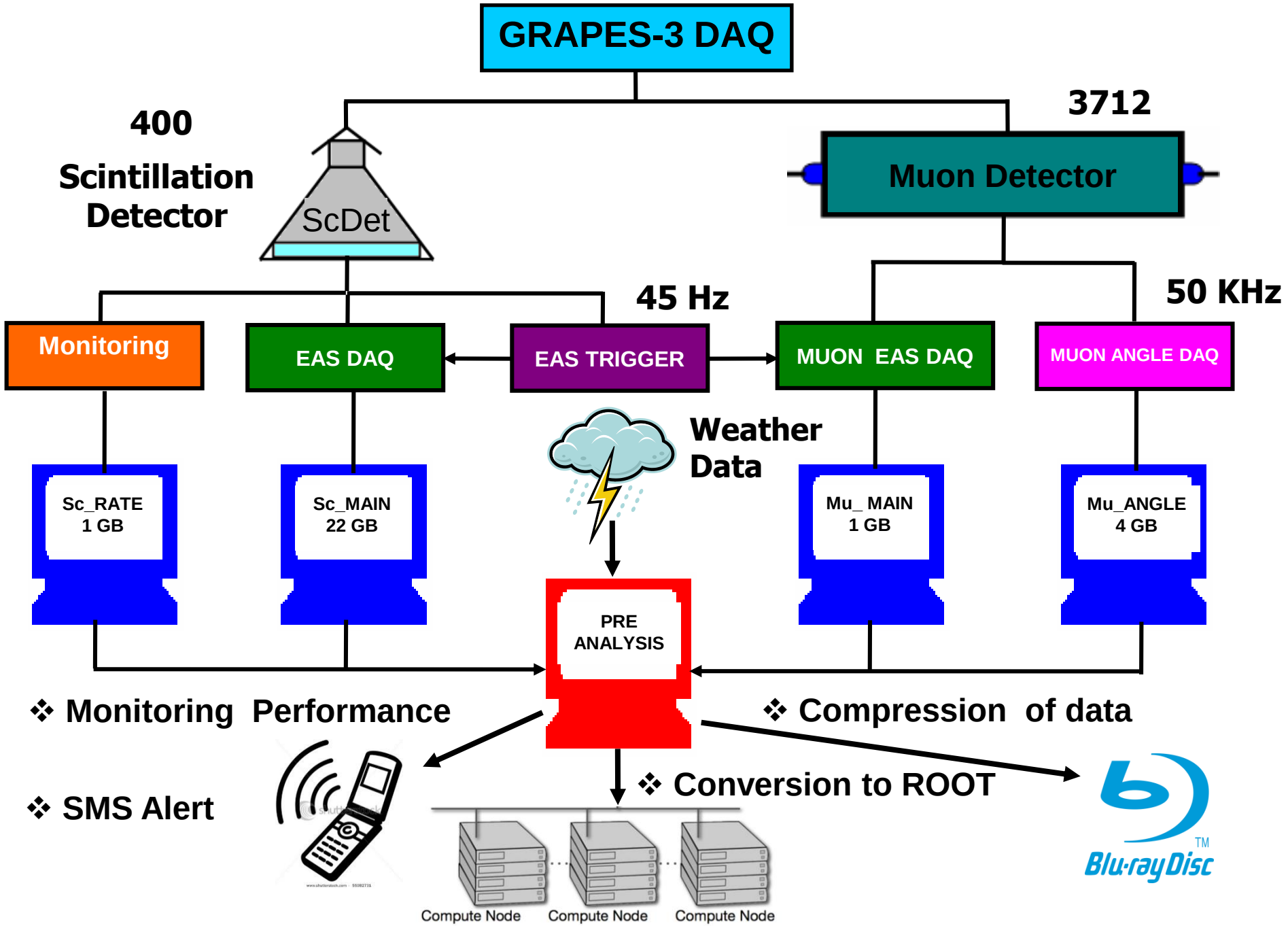

8 Feb 2019
1
2
3
4
5
6
7
8

Proportional Counter Performance



Fe_peak : 6.4 keV
Zn_peak : 8.6 keV
Mu_peak : 20.0 keV

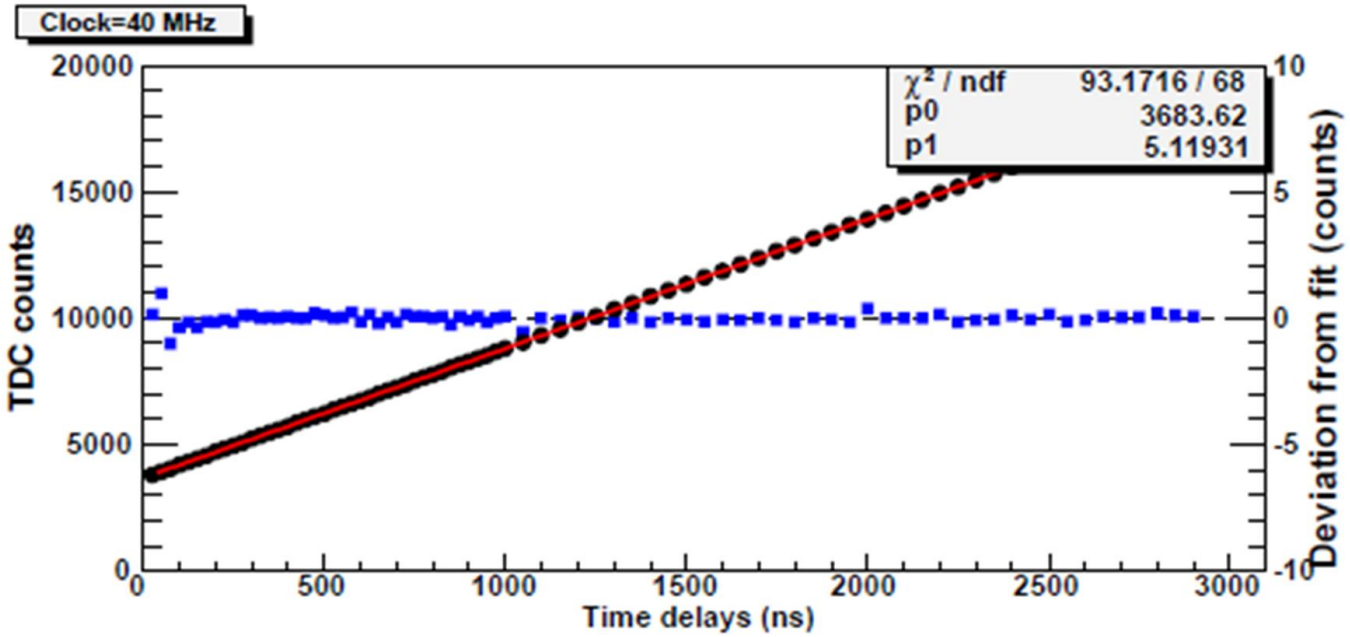
- The muon tracking telescope provides a high statistics, directional measurement of the muons, and permits small changes of ~0.1% in the muon flux to be accurately measured on a time scale of ~5 min

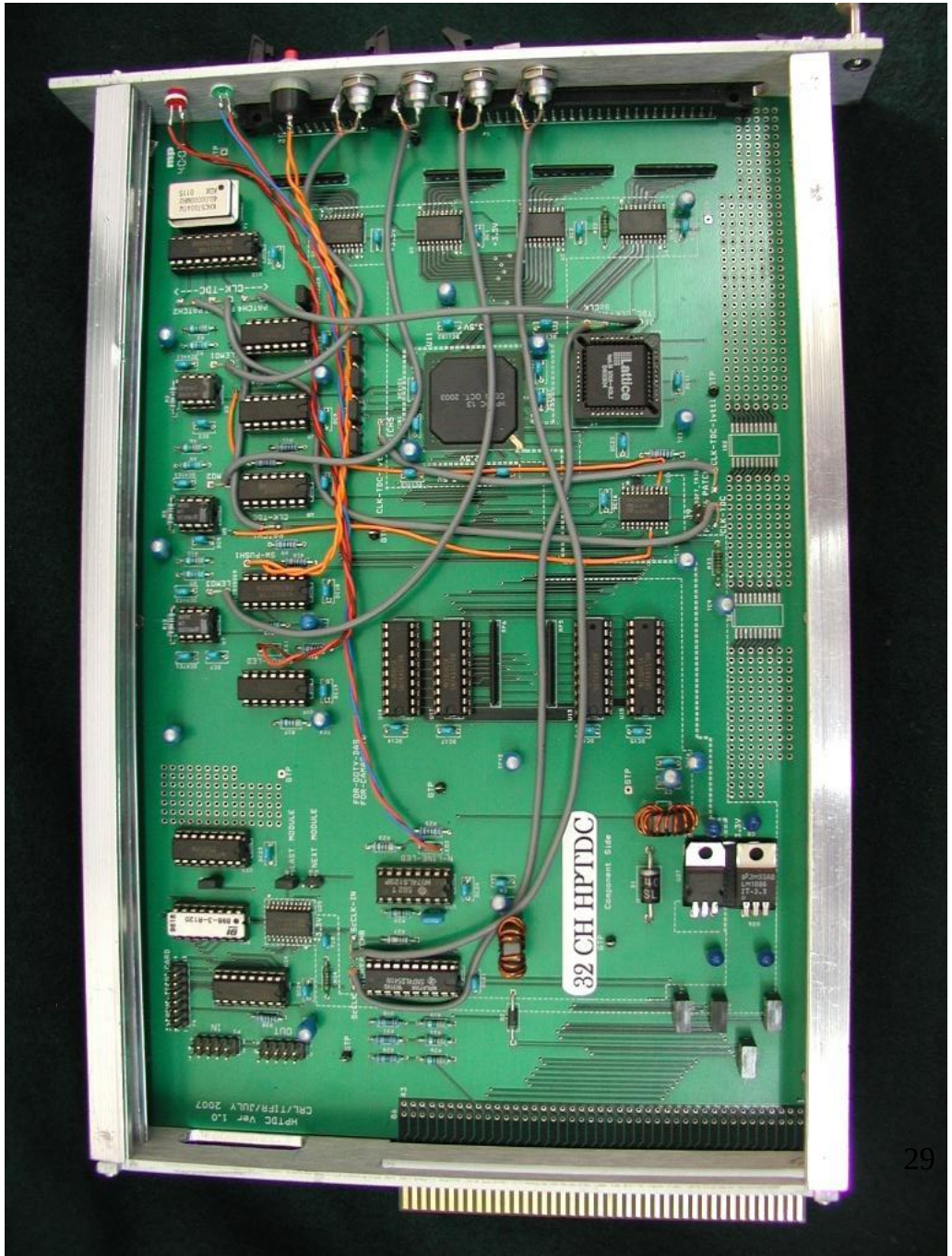


GRAPES-3 Computer Cluster

GRAPES-3 High Performance Time to Digital Converter (HPTDC)

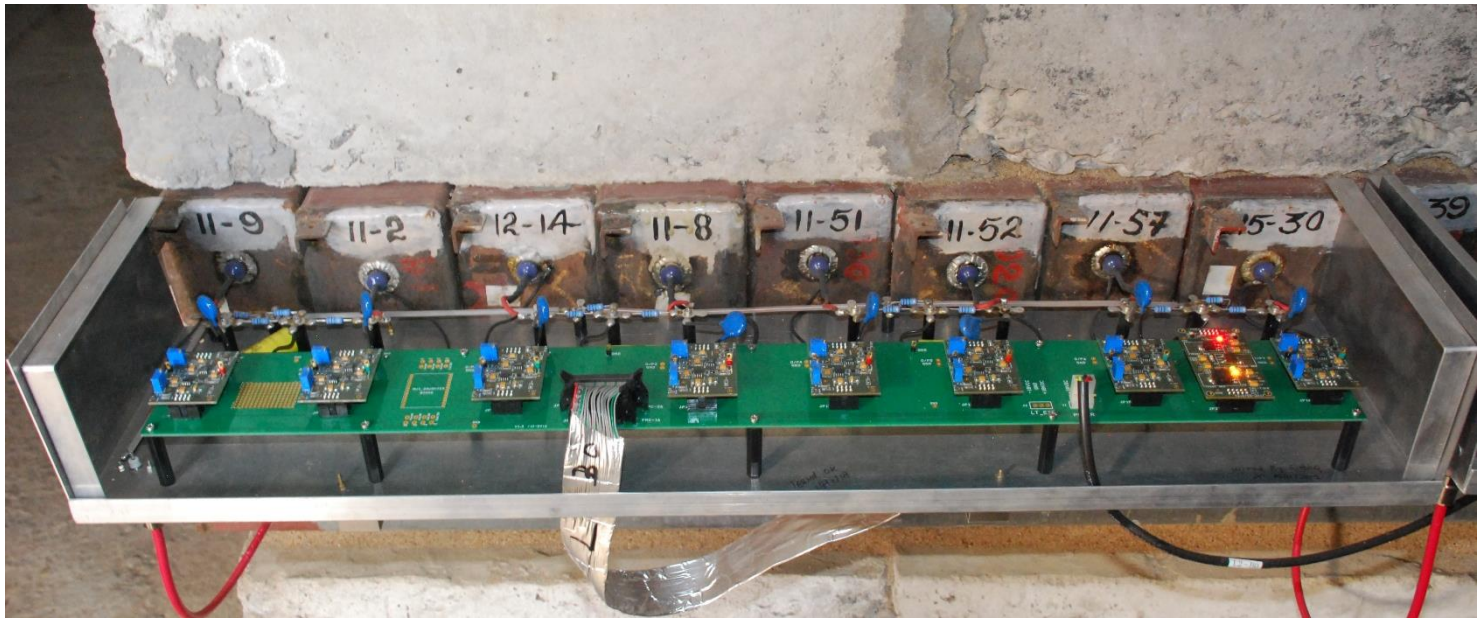
- ✓ 32 Channel CAMAC Interface in Single Module
- ✓ 24 psec Resolution
- ✓ External Clock 40 MHz. (Internally 80,160,320 MHz)
- ✓ Dynamic Range 51 µsec
- ✓ Double Pulse Resolution 5 nsec
- ✓ Trigger Mode of Operation

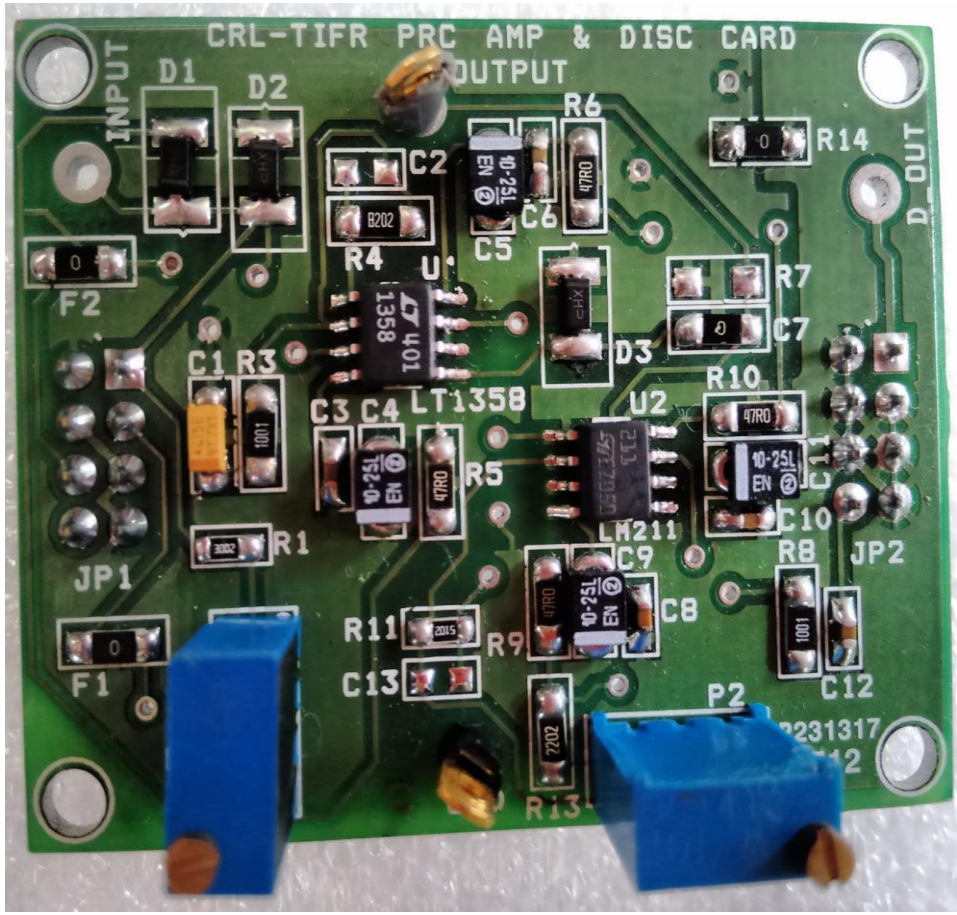




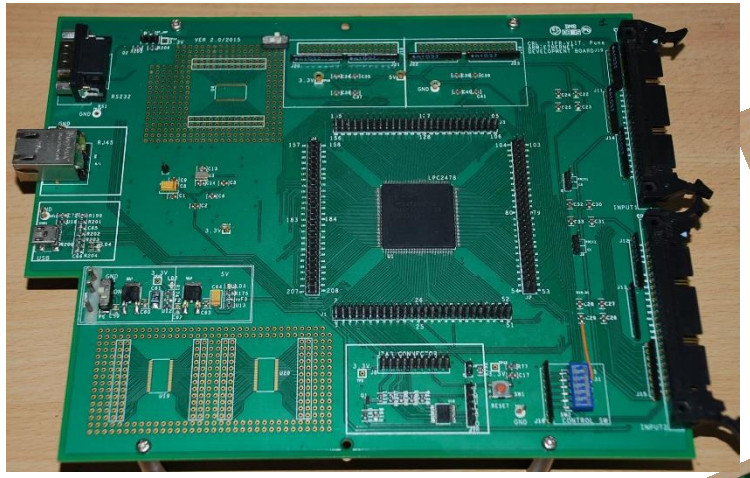
GRAPES-3 Integrated Amplifier and Discriminator Card for Proportional Counter

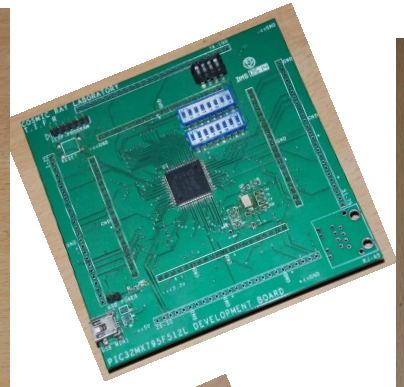
- ✓ Programmable amplification and decay constant adjustment
- ✓ On board protection for transient voltage and short circuit
- ✓ Compact card with plug and play design
- ✓ 7244 / 8000 cards are ready
- ✓ 2060 has been installed

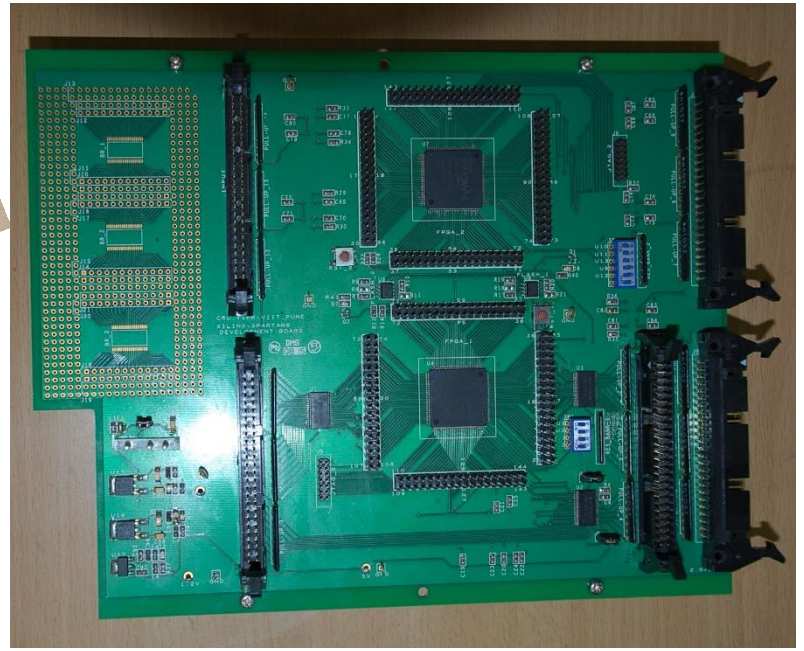


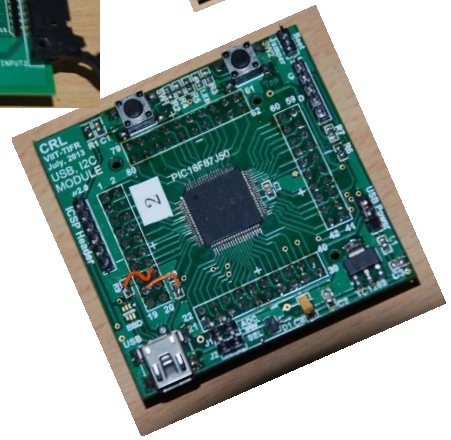


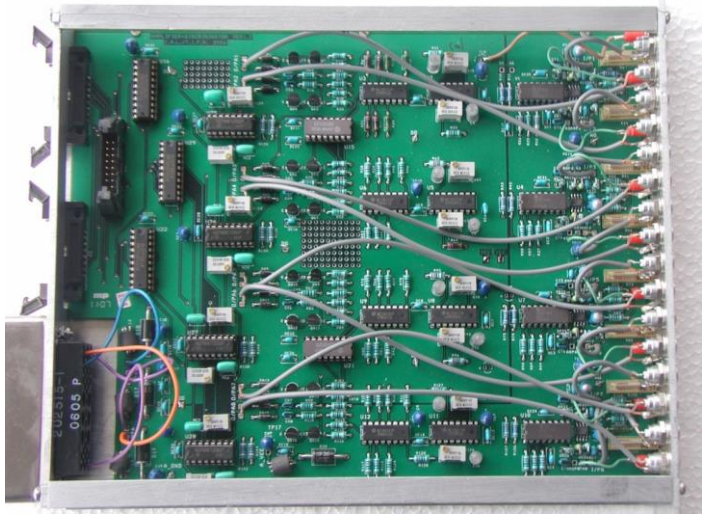
Building Blocks





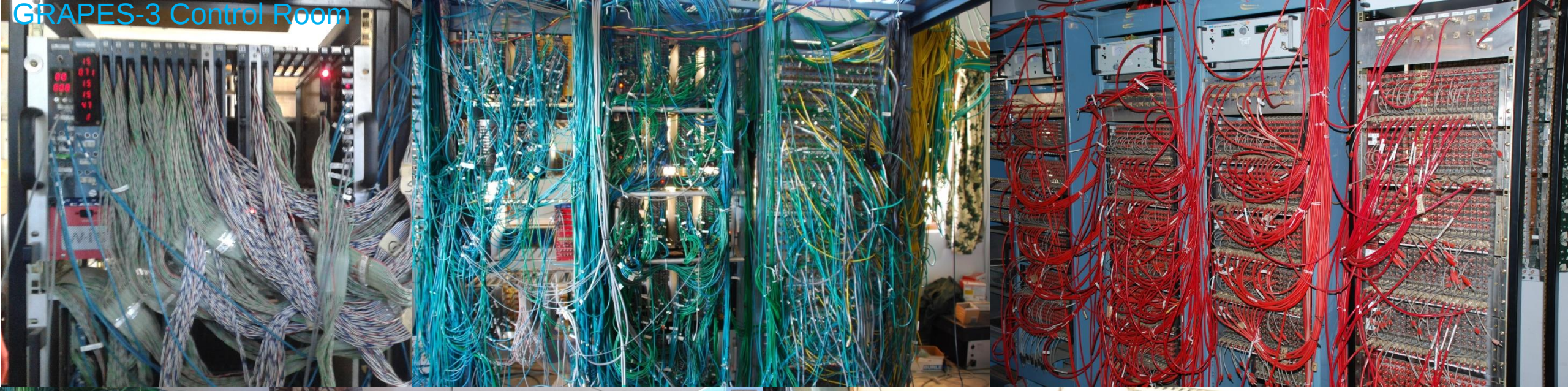


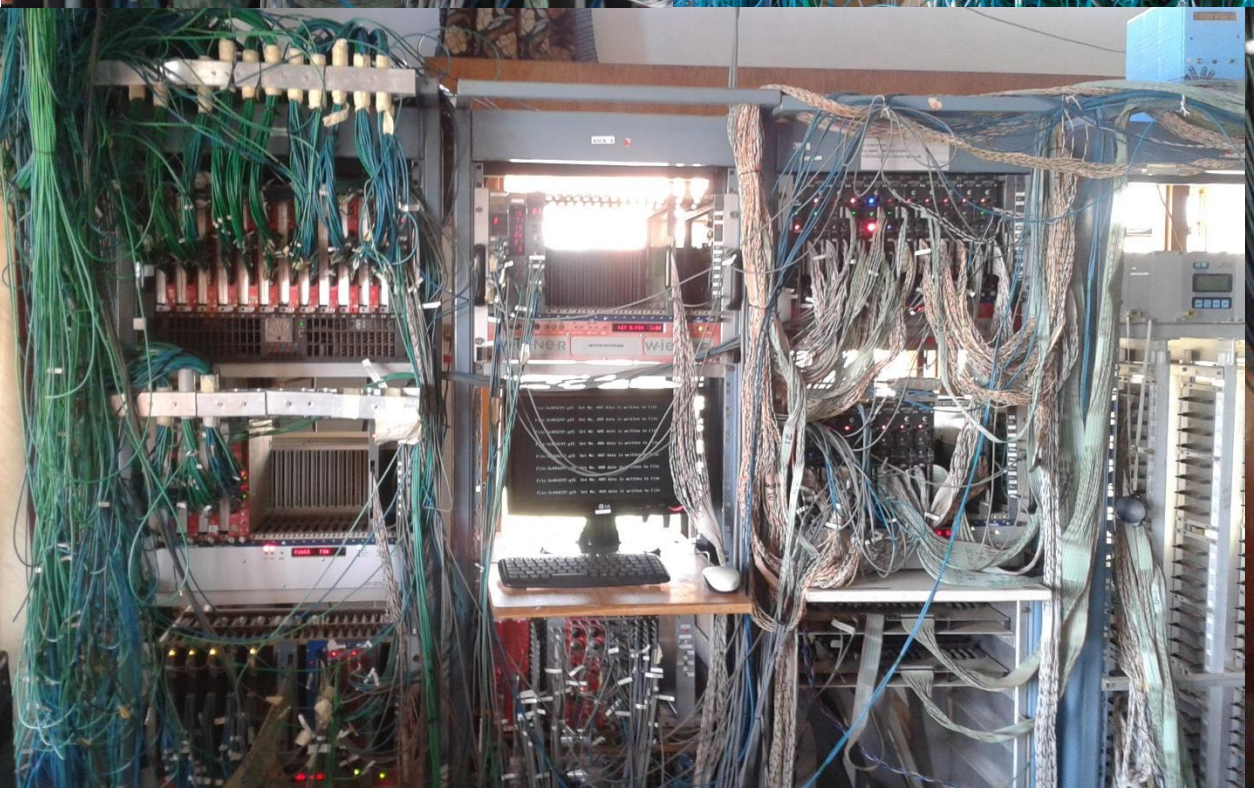


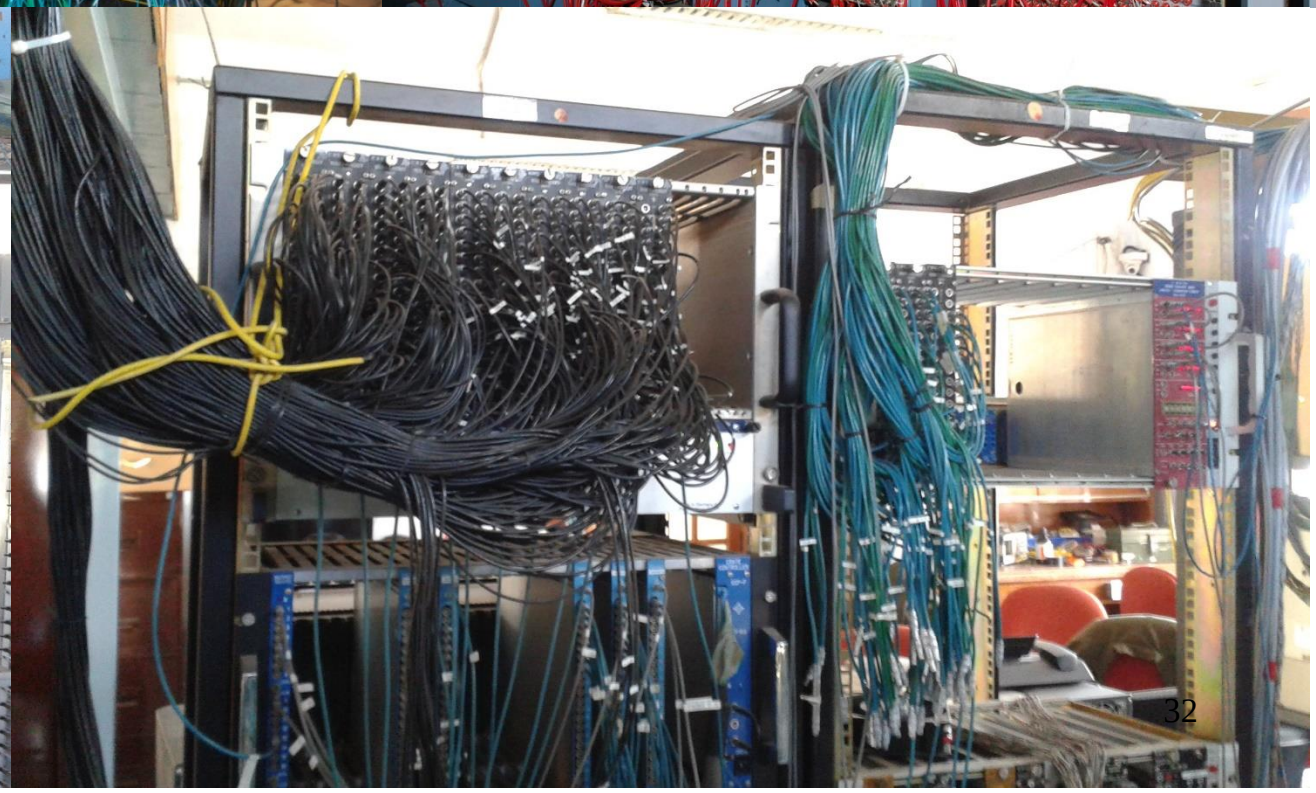


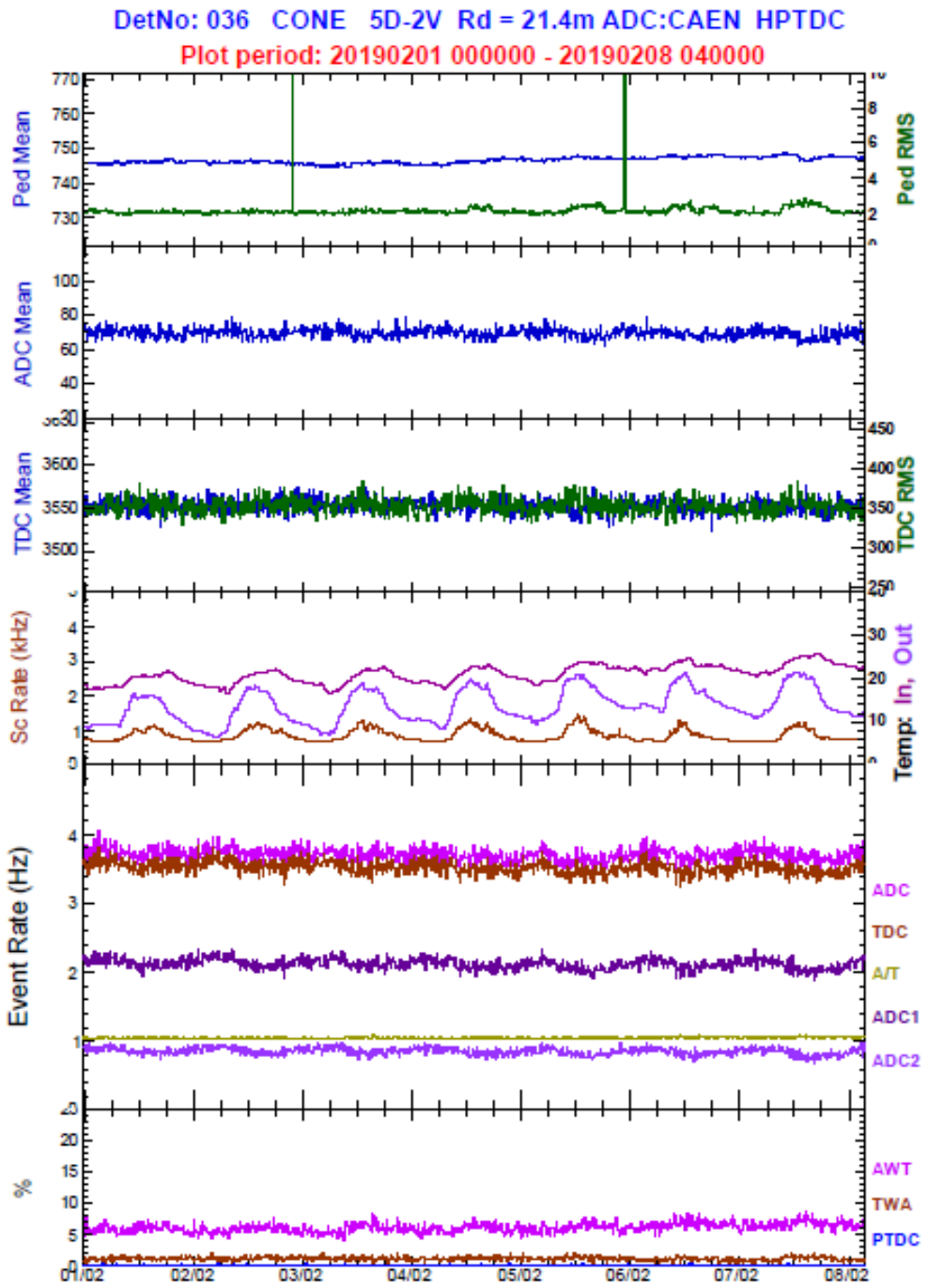
- 8 channel Integrated Fast Amplifier and Discriminator module
- FPGA based pulse width analyser
- Multipurpose fast logic unit and scalar module
- TCP/IP interface board for 32 Digital I/O's
- USB interface board for 16 Digital I/O's
- 32 channel HPTDC
- High voltage monitoring system
- Temperature Scanner and Controller
- TTL to optical link

GRAPES-3 Control Room



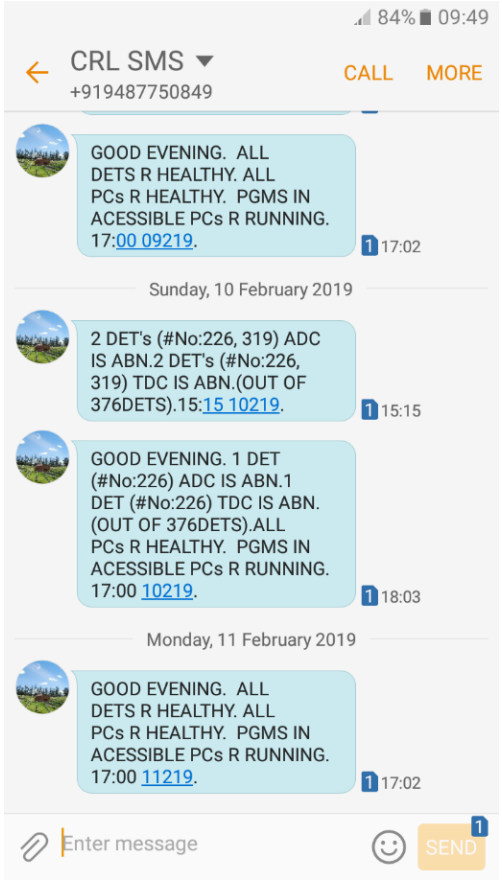






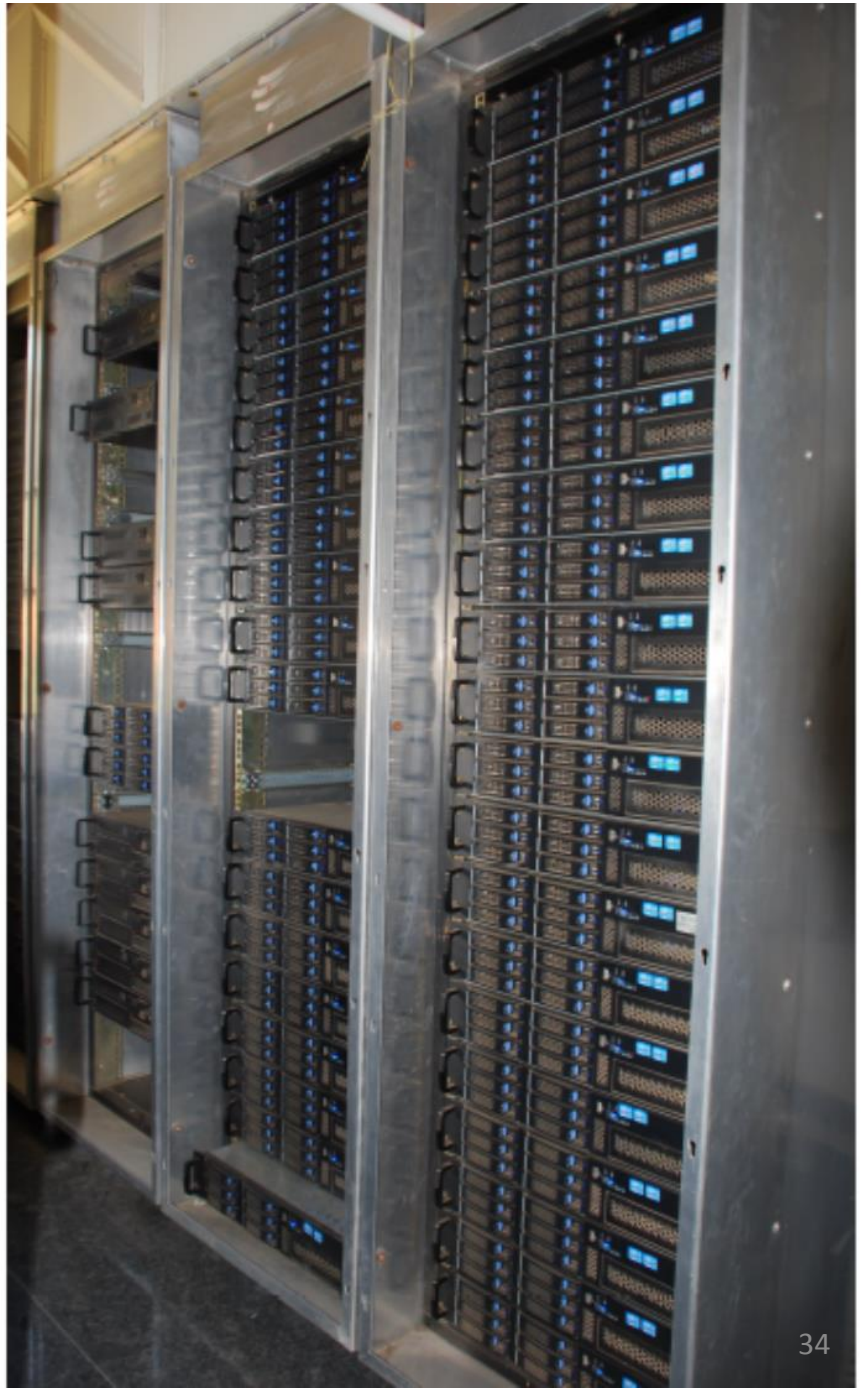
GRAPES-3 Monitoring Tools

- ROOT based data analysis tools
- Web based parameter monitoring
- SMS alerts in case of abnormality in DAQ



GRAPES-3 Computer Cluster

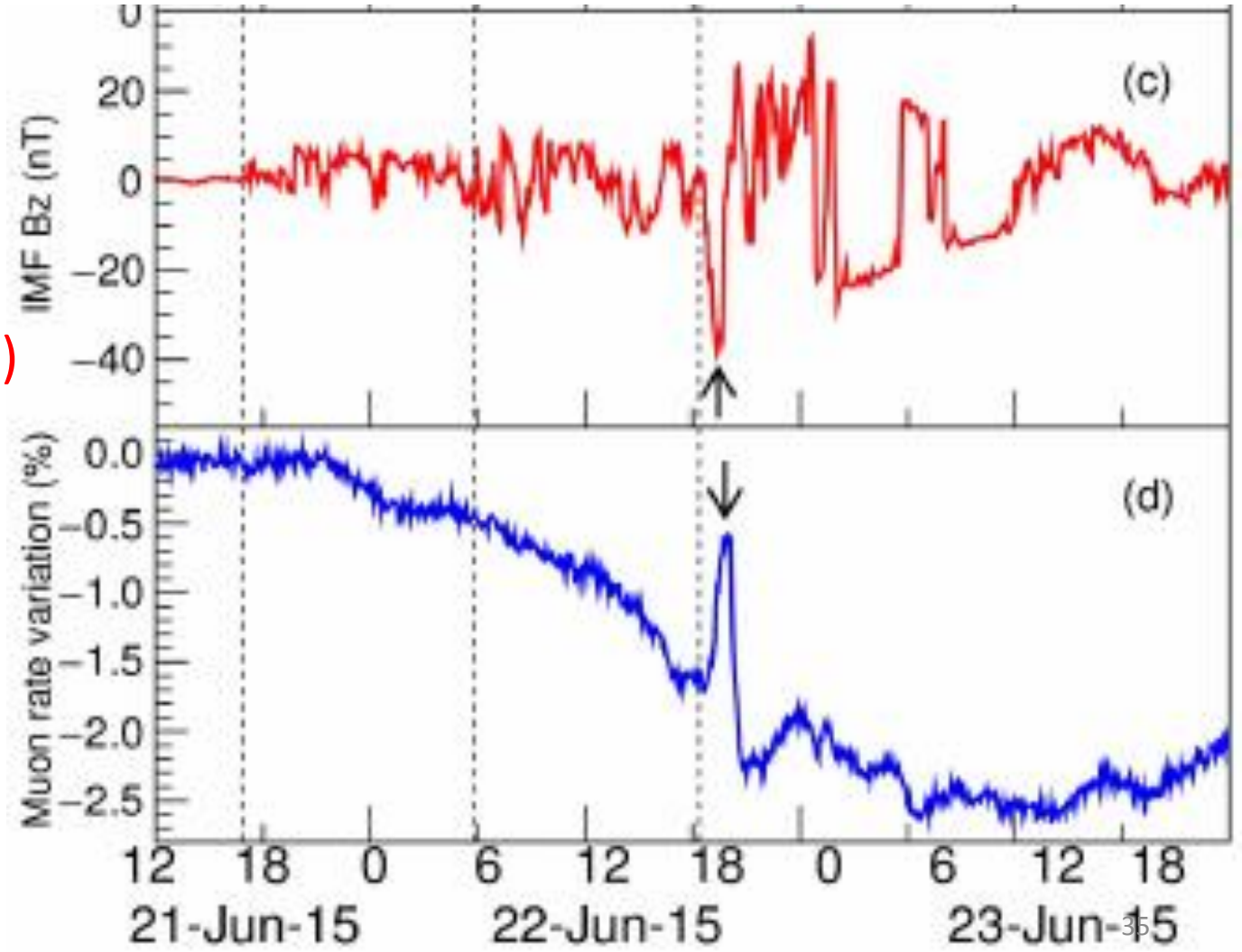
- Nodes – 40
- Memory – 1280GB
- Storage – 660GB
- Optical N/W – 10Gbps
- Rocks Cluster Ranking – 36



Transient Weakening of Earth's Magnetic Shield Probed by a Cosmic Ray Burst

Interplanetry magnetic field (IMF)
Data from OMNI Web
Measured by wind space craft
Located at L1 (1.5 million kms from Earth)

Muon Flux Variation
Data from GRAPES-3 experiment,
Measured by Muon Tracking Telescope
Located at Ooty, India



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How India uses recycled pipes to detect ferocious solar storms

Soutik Biswas
India correspondent

1 March 2017 | India | Share

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THE LARGEST CIRCULATED ENGLIS

COIMBATORE | SATURDAY 5

Karaikal district of Puducherry and four others from Jagathapatnam in Tamil Nadu's Pudukkottai District were repatriated from Sri Lanka by Indian Coast Guard

Scientists and other staff at the Cosmic Ray Laboratory in Ooty. – DC

COSMIC RAY LAB SCIENTISTS TRACK SOLAR STORM

B. RAVICHANDRAN | DC
OOTY, NOV. 4

CRL: A SHINING EXAMPLE OF

The Madras high court has directed directors of municipal administration and water supply department and town planning and the commissioner to file their reply for not taking part in a committee meeting convened to discuss the arrangements to be made to face the ensuing monsoon.

The first bench of Chief Justice Sanjay Kishan Kaul and Justice R. Mahadevan, ... before which a PIL, filed by A. Narayanan, of Chengalpattu district came up for hearing on Friday, also directed chairman and managing director, Chennai Metro Water Supply and Sewerage Board, who is chairman of the committee, for convening meeting violating the orders of the high court.

The petitioner in his PIL sought for direction to authorities concerned ... "Let all the three offi...

The directors of municipal administration and water supply department and town planning and the commissioner did not participate in the meeting. The petitioner, thus, has legitimate grievance that no progress could be achieved, unless there is coordination between them.

DH
DECCAN HERALD
Thursday 23 March 2017
News updated at 3:28 PM IST

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You are here: Home » Supplements » Science & Technology » Breach in Earth's magnetic field

Breach in Earth's magnetic field

Palahalli R Vishwanath, Dec 20, 2016,

Detrimental

It is known that solar storms can cause major disruption to human civilisation by crippling large electrical power grids, satellite operations and communications. In the early hours of June 21, 2015, a NASA spacecraft recorded particles blasting off the Sun at roughly 1,300 km per second. It was a solar flare. Forty hours later, a severe geomagnetic storm knocked out radio signals in North and South America and the Aurora Borealis was spotted as far south as Texas in the United States.

This storm was described as one of the most powerful (four, on a scale of five) in recent history. Recent results from a cosmic ray experiment in India, published in Physical Review Letters in November 2016, show that the solar storm resulted in weakening the Earth's magnetic field, allowing high energy cosmic rays. The result has attracted considerable attention with possible application to prediction of space weather.

Earth's magnetosphere

It was in 1600 that William Gilbert, a physician, demonstrated that Earth behaves like a giant

GRAPES-3 indicates a crack in Earth's magnetic shield

phys.org/news/2016-11-grapes-earth-magnetic-shield.html

APS physics | Physics

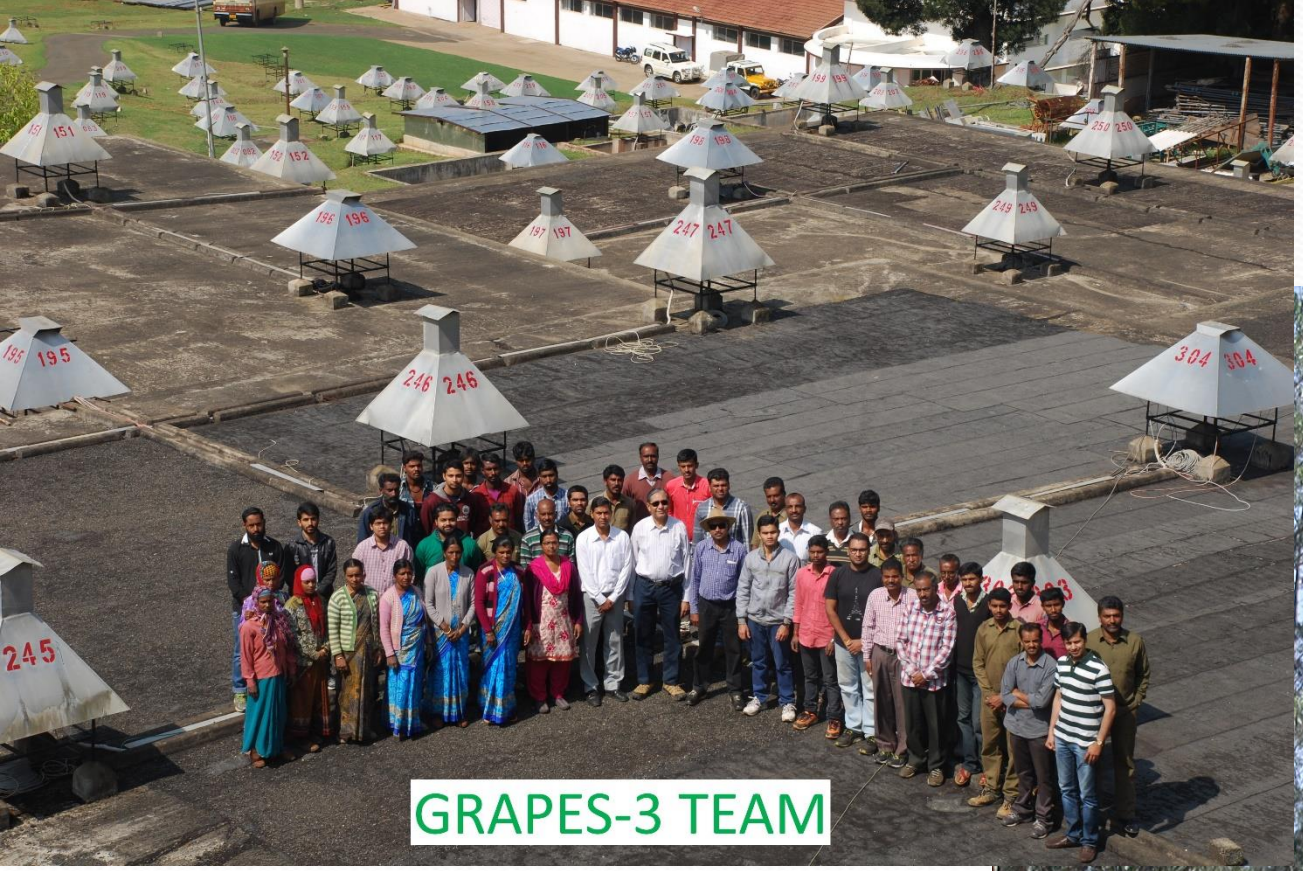
Synopsis: A Crack in Earth's Protective Shield

October 20, 2016

Observations with India's cosmic-ray telesc
weakened during a 2015 geomagnetic storn

Web : grapes-3.tifr.res.in

Email : atul@crl.tifr.res.in



Thanks