Development of Particle Detectors at TIFR for Underground Experiments- Then and Now

Naba K Mondal, INO Cell, TIFR

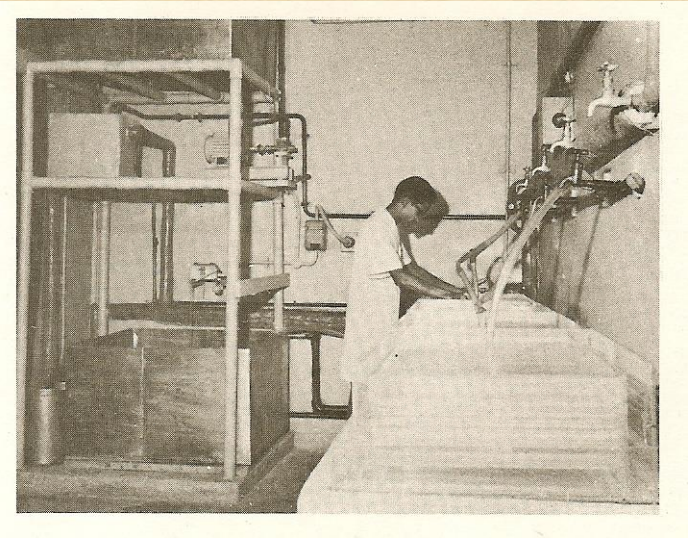
Prelude

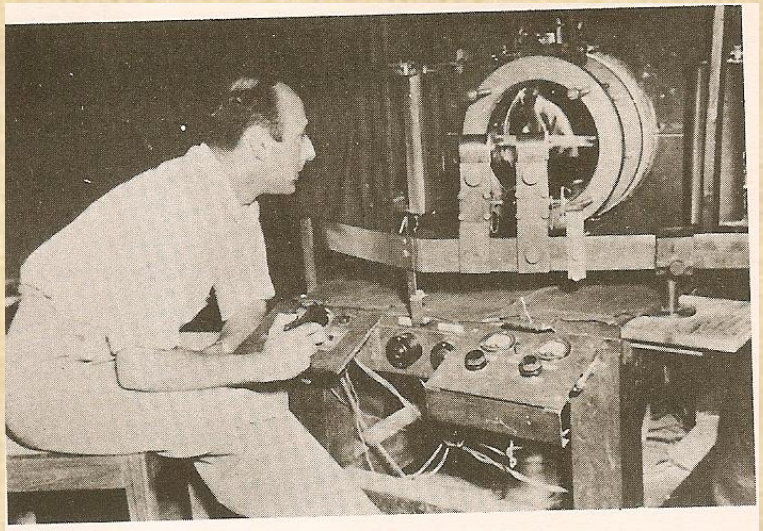
Cosmic Ray Research Unit at Bangalore

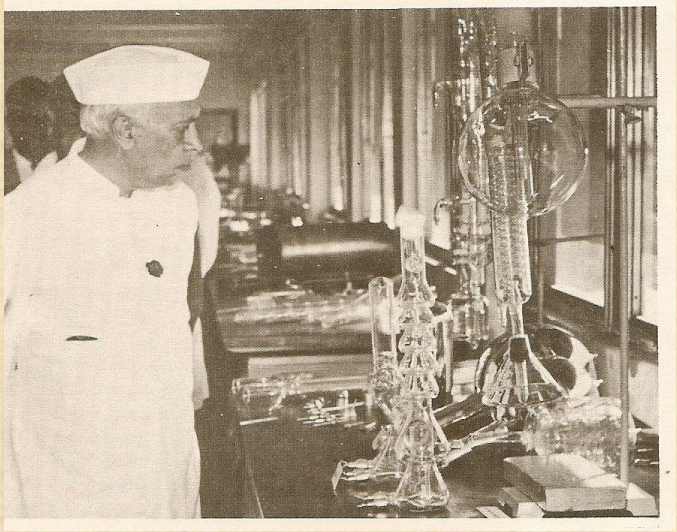
- *Seeds for Experimental High Energy Physics research at TIFR were really sown even before TIFR came into existence on 1st June, 1945.*
- *In December, 1944 Homi Bhabha flew two telesopes with GM counters sandwitched with lead plates using US airplanes stationed at Bangalore during the war.*
  - *First measurement of high altitude meson intensities at equatorial latitude.*
- *Built a 12" circular cloud chamber similar to one available at Blackett's Lab in UK.*
  - *Used it to study the scattering characteristics of mesons*

Early Particle physics experiments at TIFR

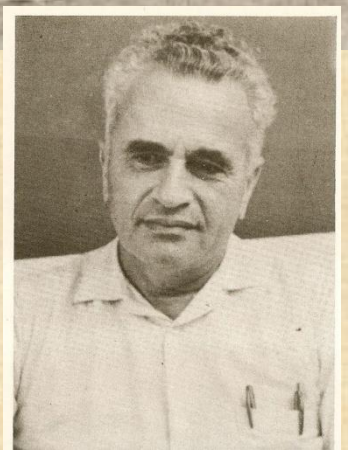
- Cloud Chambers.
- G.M. Counters.
- Emulsions.







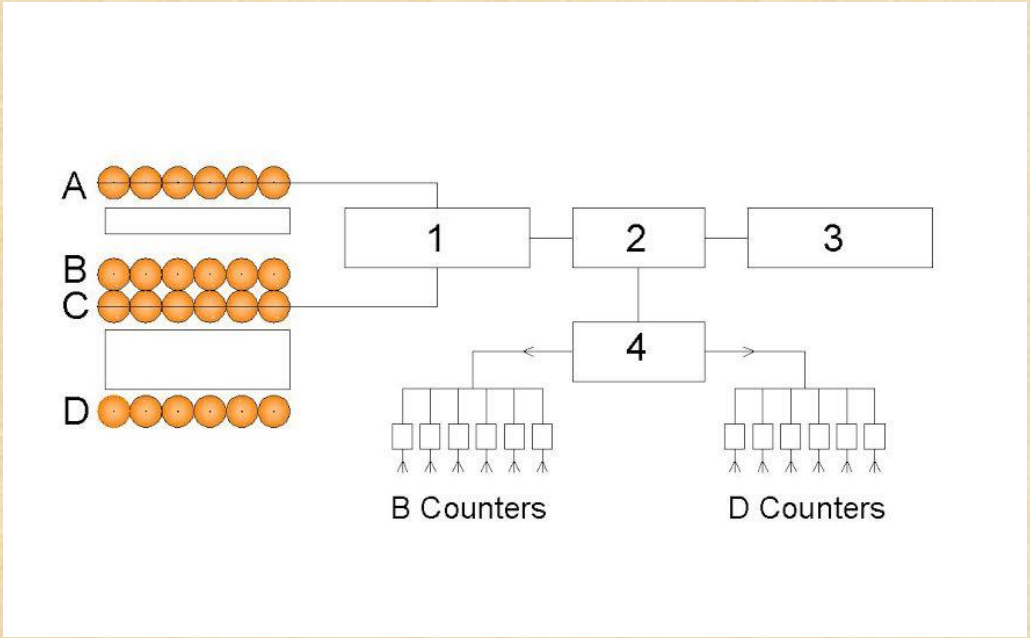
Conference on Elementary Particles at TIFR in 1950

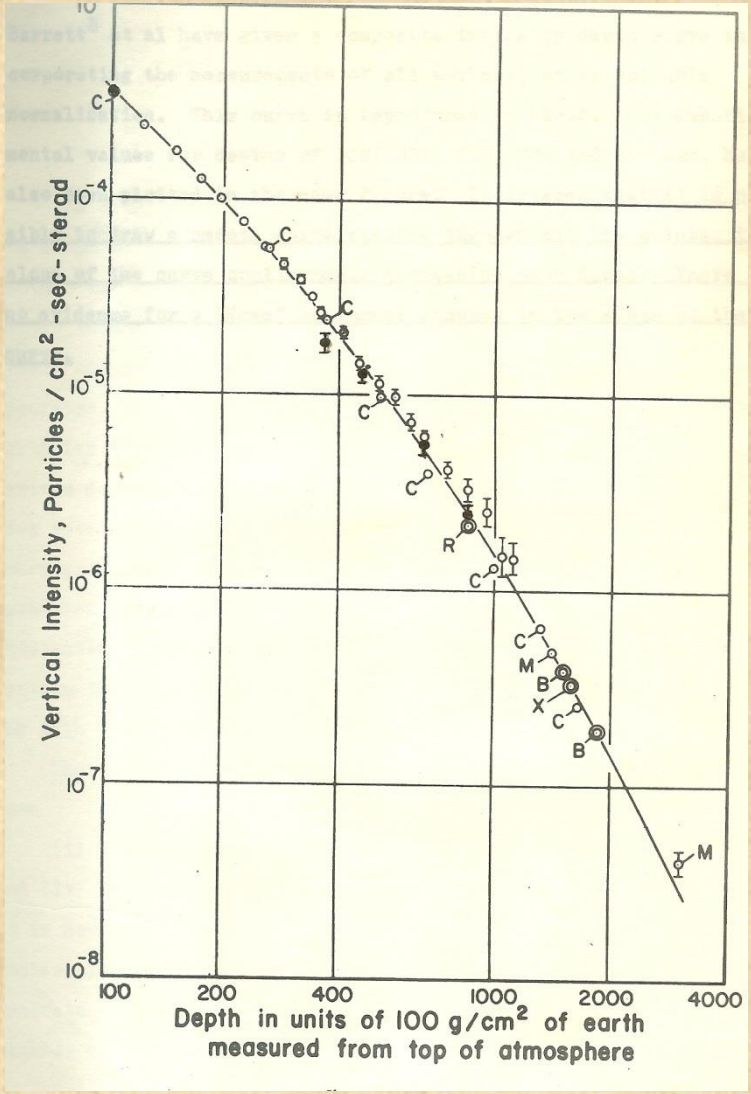


1951 Start of KGF activities

First set of measurements were carried out at Nundydurg Mines

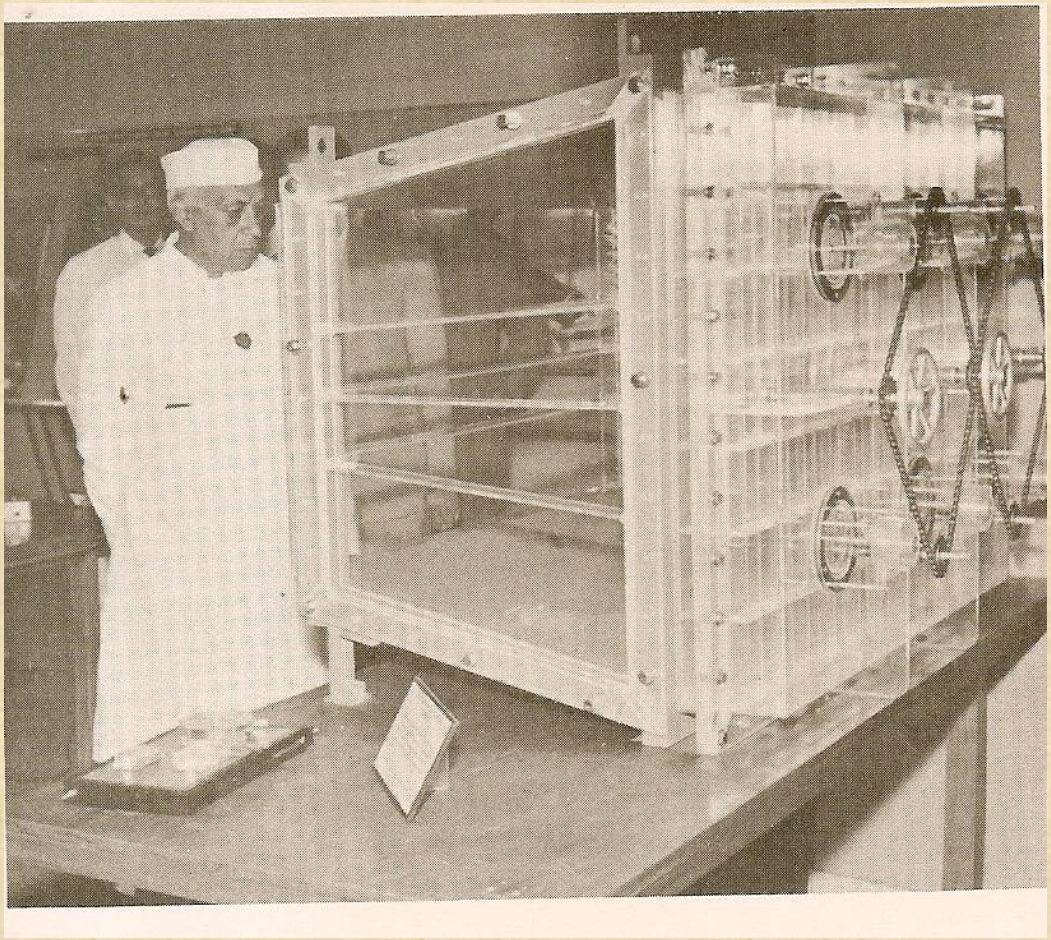
KGF 1951-1954 - GM Counter array upto a depth of 900 ft (E_μ ~ 200 GeV)



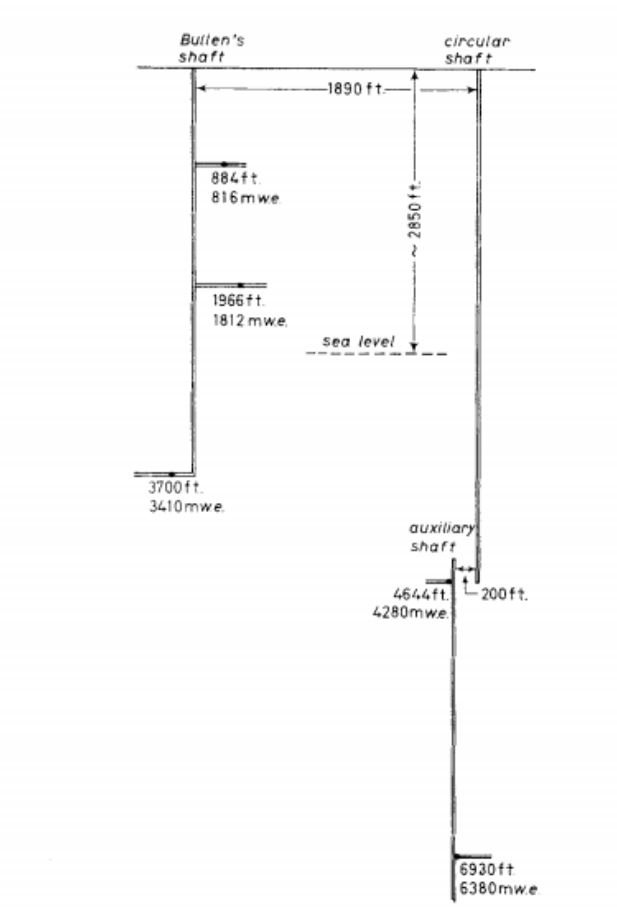


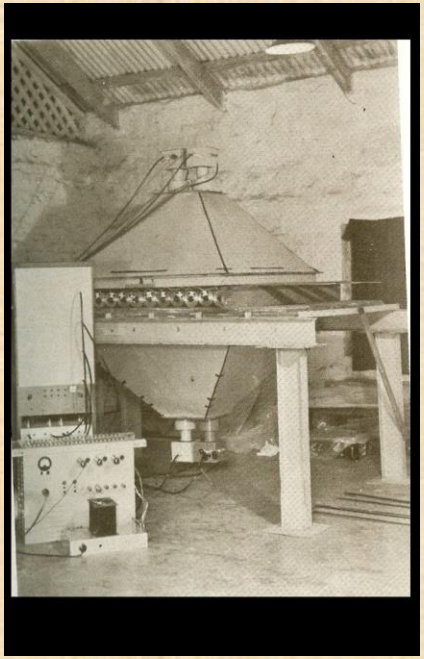
1. Double coincidence circuits.
2. Cathode follower.
3. Film advancing circuits.
4. Inverter.

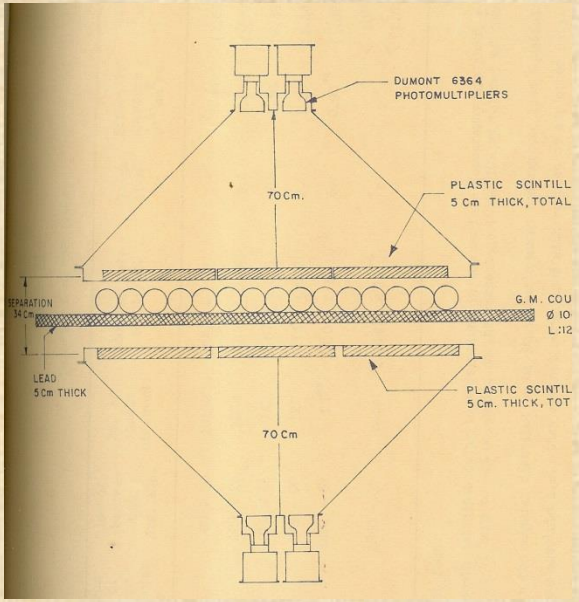
Large Cloud Chamber



KGF 1960-1963
Up to a depth of 2.7 km. (800 – 8400 mwe)

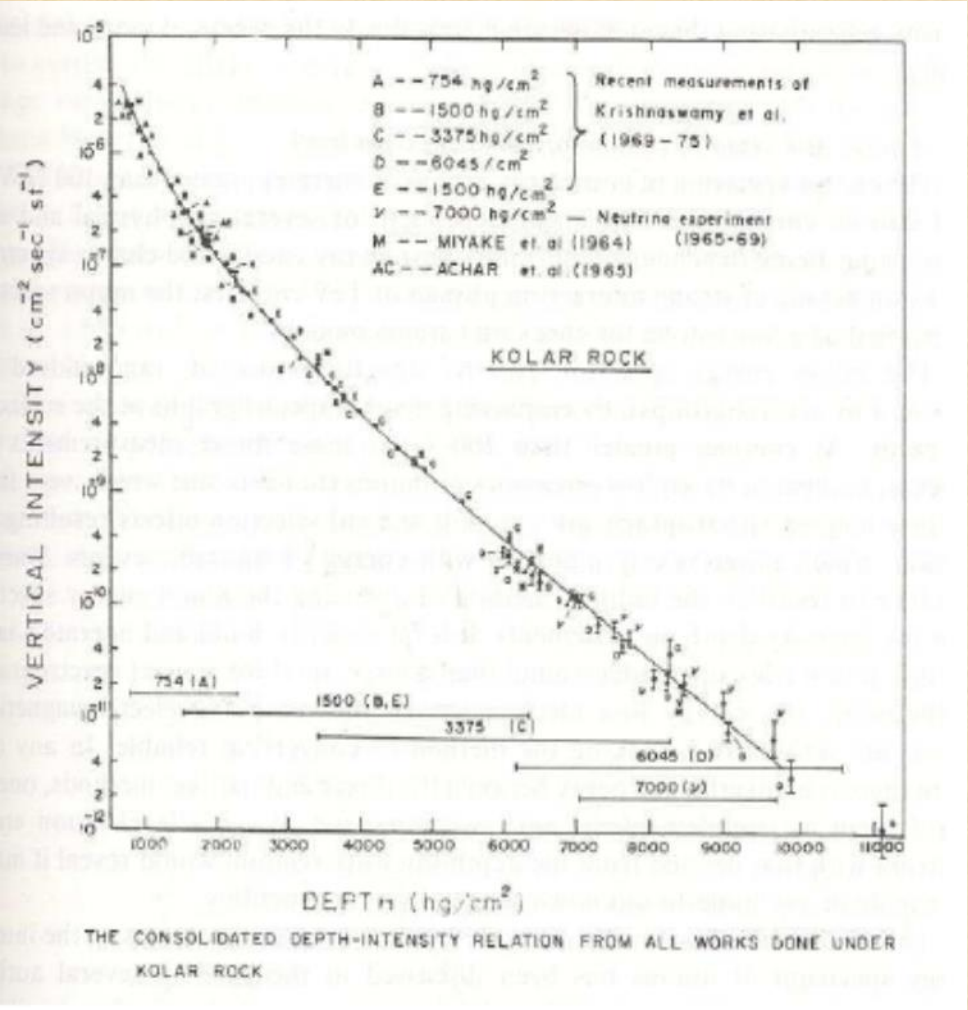






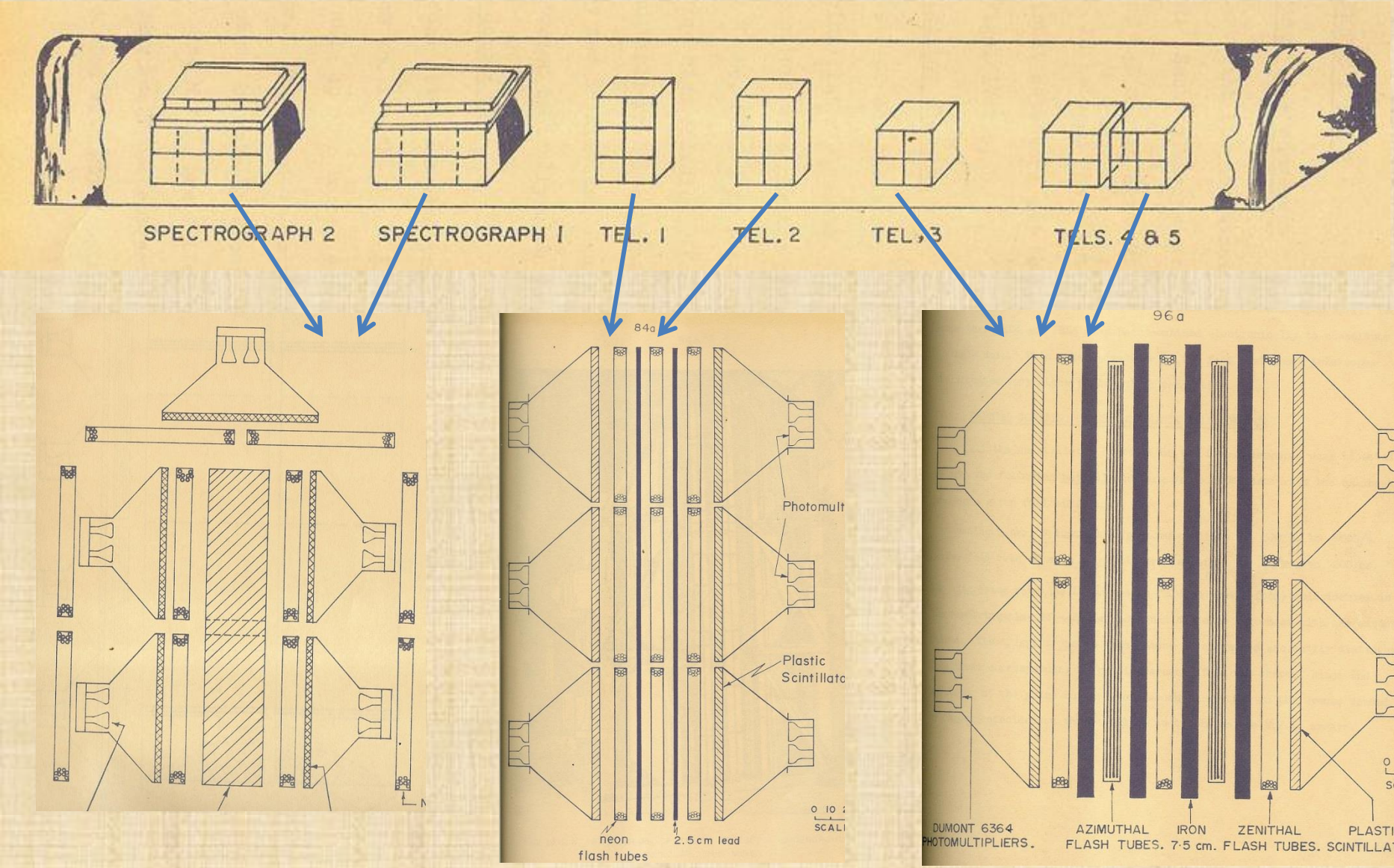
Miyake, Narasimham, Ramanamurthy

Most comprehensive Depth-intensity curve

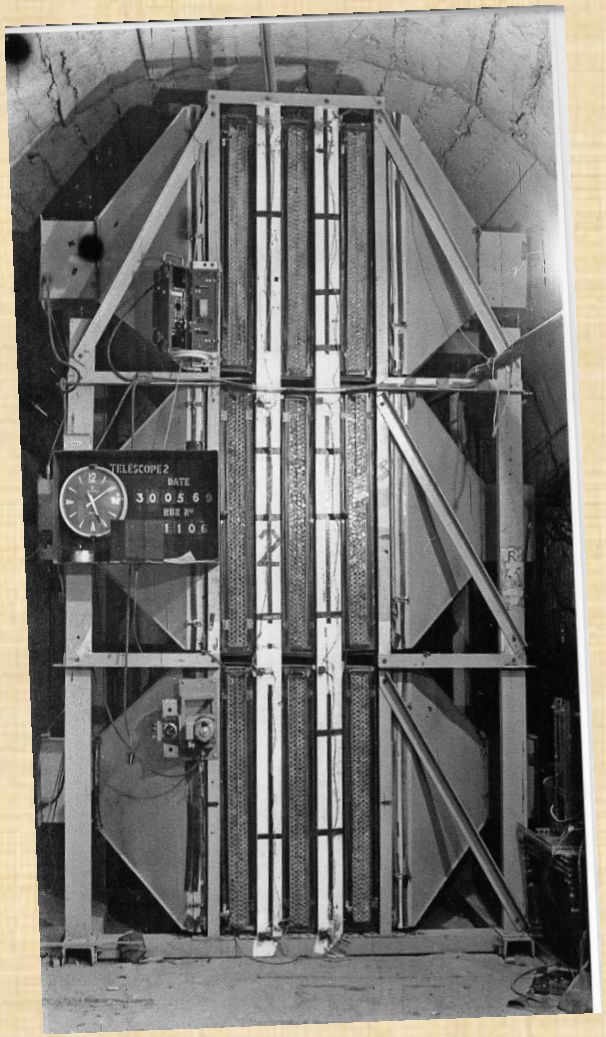


THE CONSOLIDATED DEPTH-INTENSITY RELATION FROM ALL WORKS DONE UNDER KOLAR ROCK

Neutrino Experiment at KGF 1965 onwards



Atmospheric neutrino detection in 1965



Atmospheric neutrino detector
at Kolar Gold Field –1965

DETECTION OF MUONS PRODUCED BY COSMIC RAY NEUTRINO DEEP UNDERGROUND

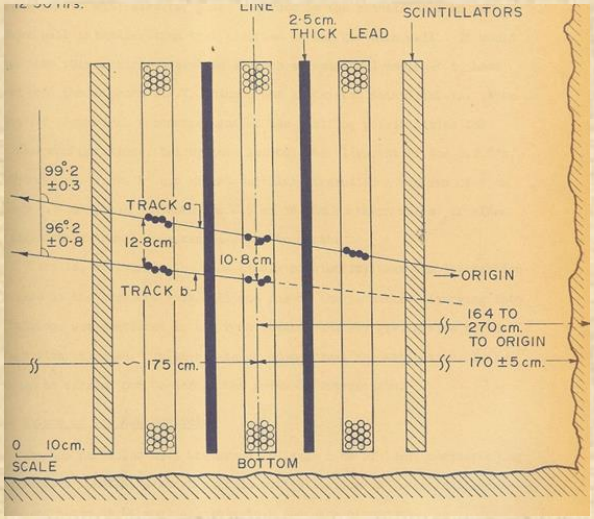
C. V. ACHAR, M. G. K. MENON, V. S. NARASIMHAM, P. V. RAMANA MURTHY and B. V. SREEKANTAN,
Tata Institute of Fundamental Research, Colaba, Bombay

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

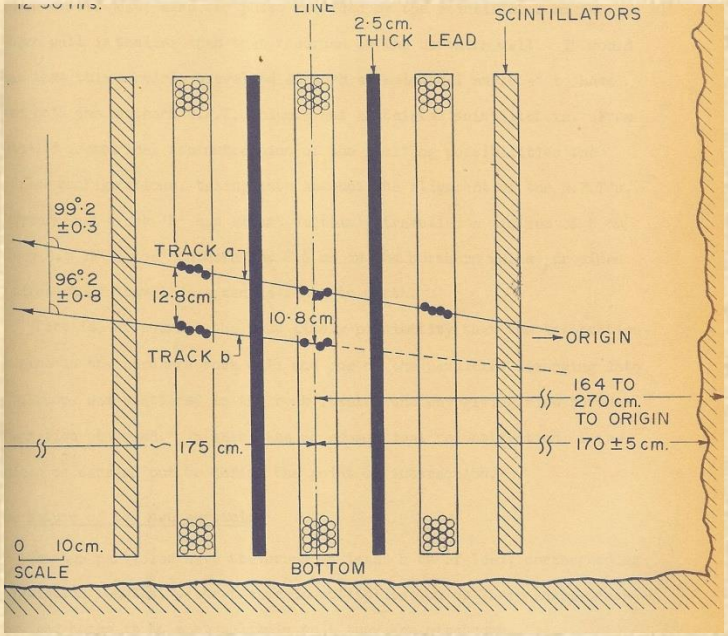
D. R. CREED, J. L. OSBORNE, J. B. M. PATTISON and A. W. WOLFENDALE
University of Durham, Durham, U.K.

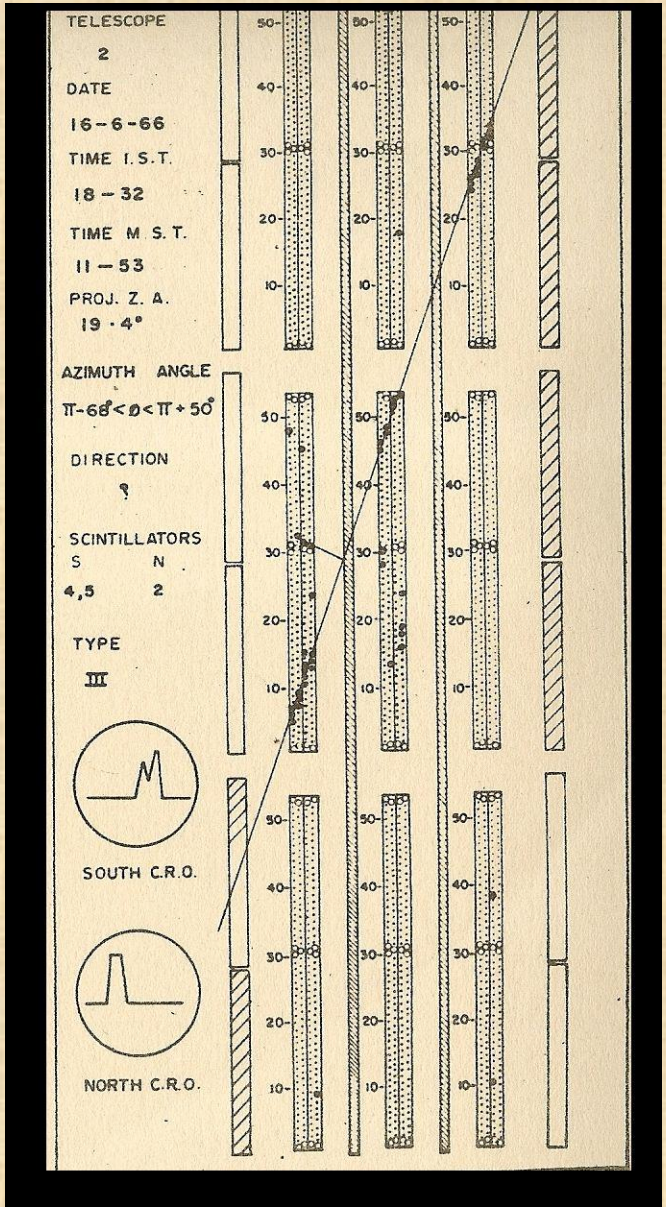
Received 12 July 1965

Physics Letters 18, (1965) 196, dated 15th Aug 1965

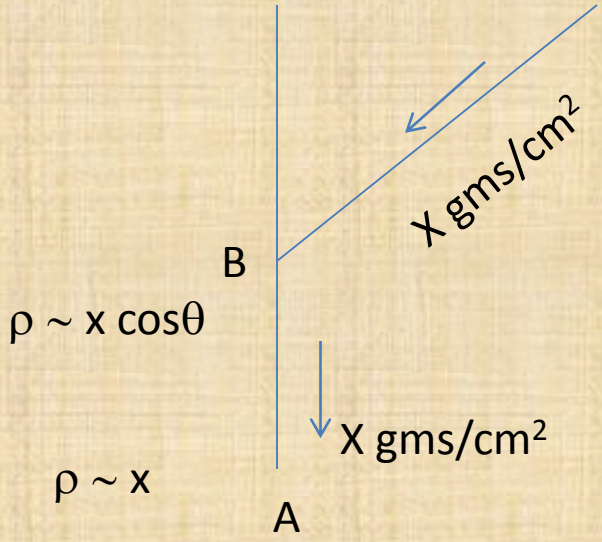


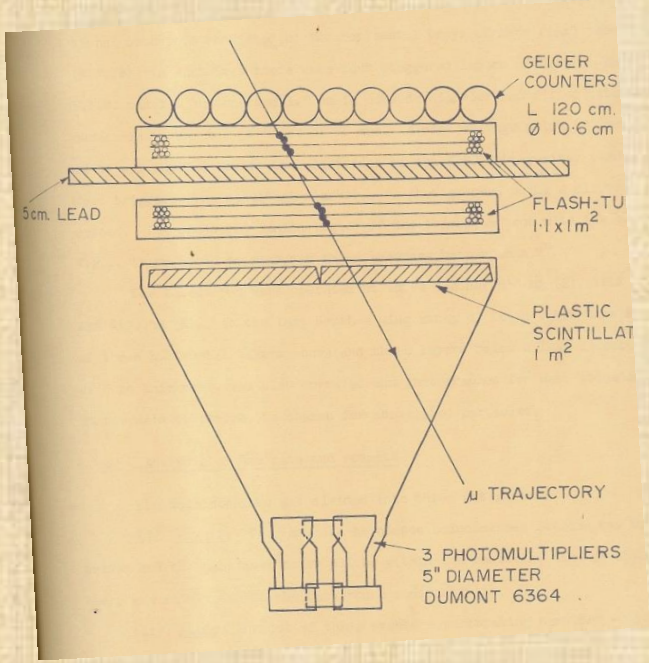
Neutrino Events at KGF





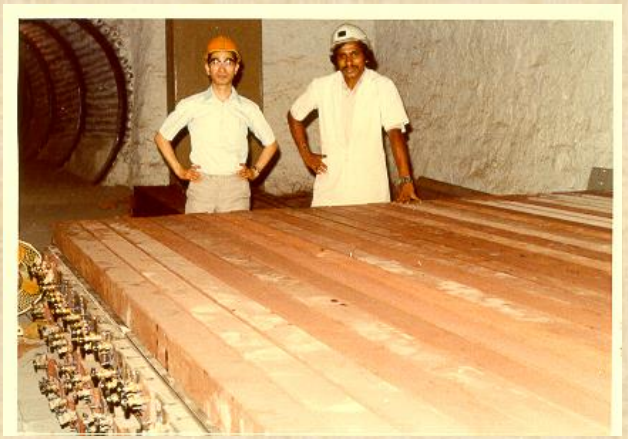
Muon Angular Distribution Deep Underground



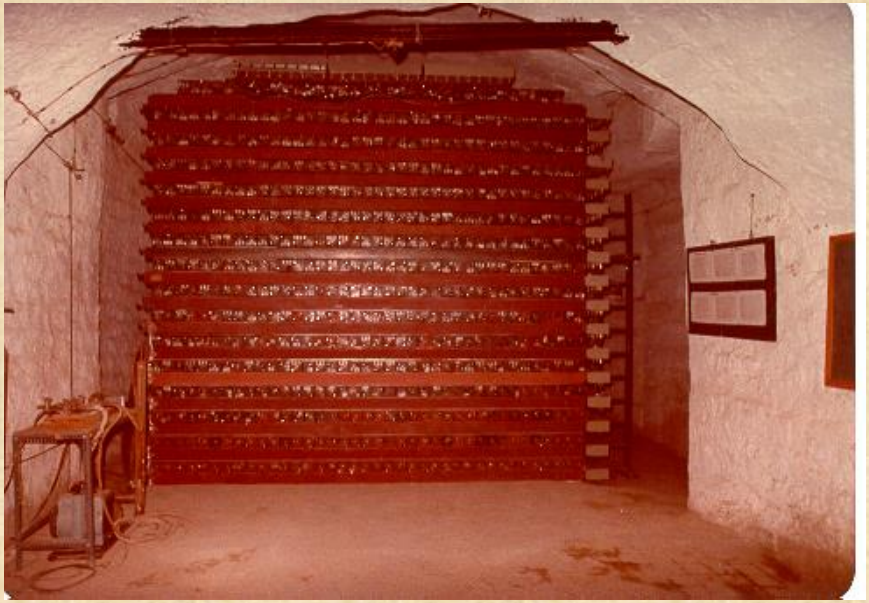


- At very small residual thickness of the atmosphere, (< 200 gms/cm^2) , the density of air is proportional to the thickness of the atmosphere itself.
- Decay probability is inversely proportional to density and thus increases as secθ
- Any deviation from this secθ will suggest new source of atmospheric muons other than pion/kaon decay

KGF Phase I Nucleon Decay Detector (1979-1992)



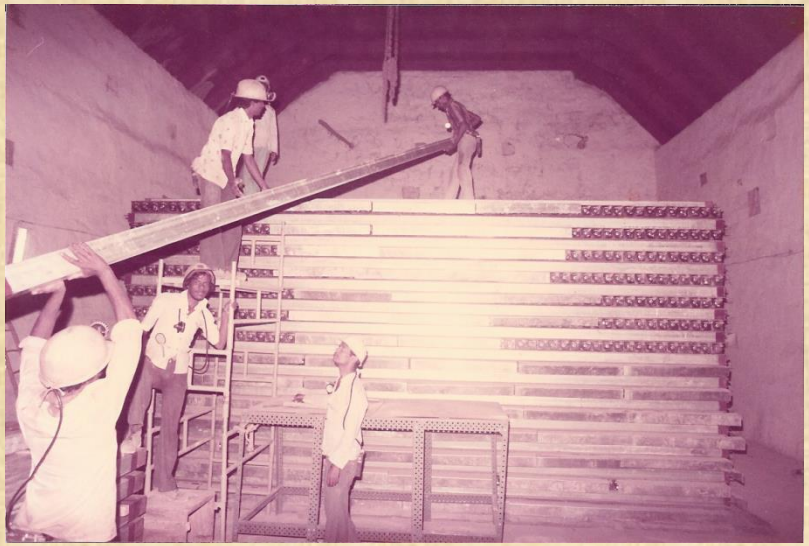
KGF Phase-I Nucleon Decay Detector



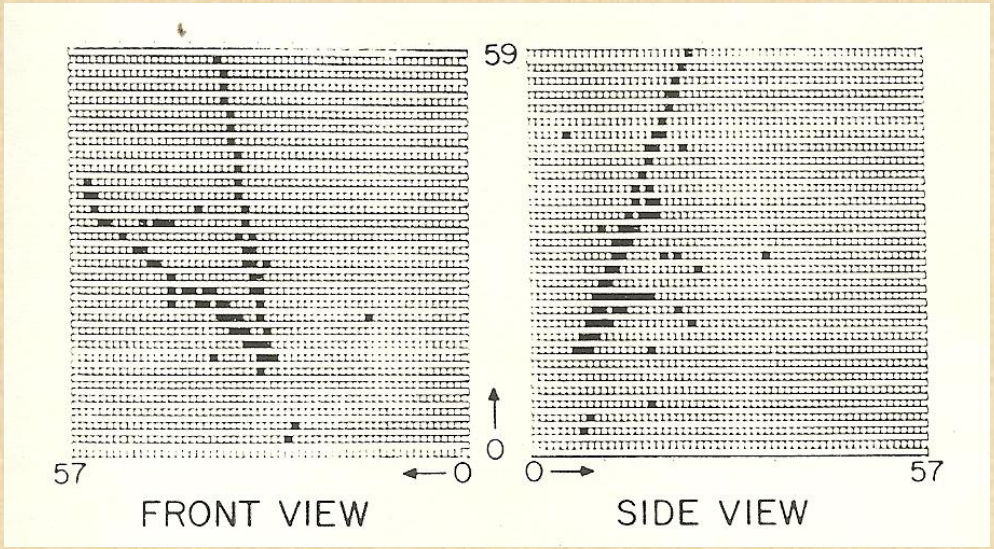
ICOBAN 1982

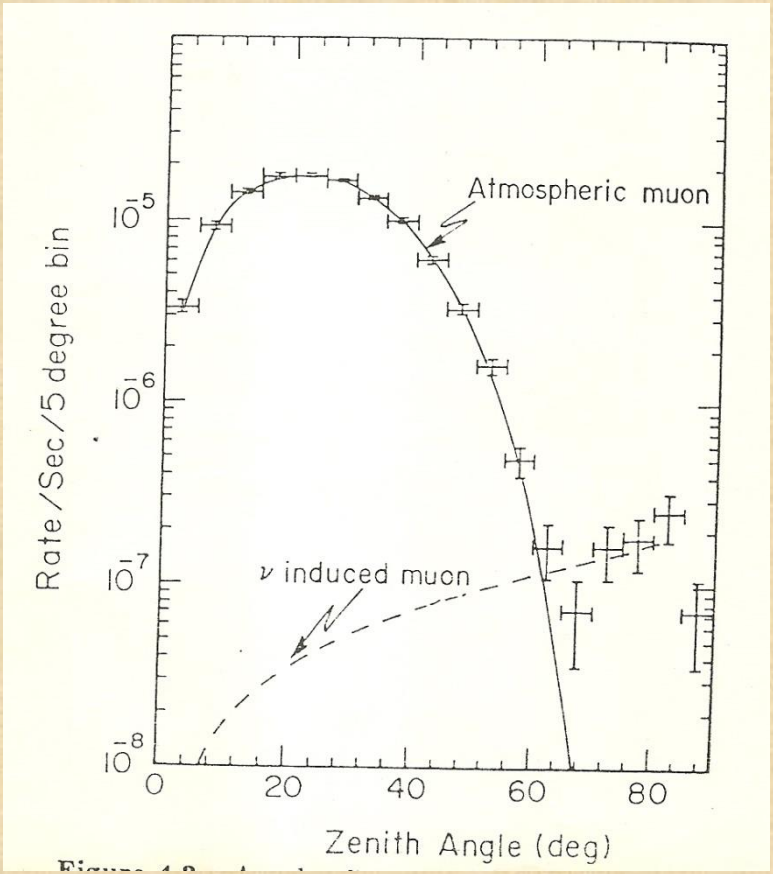
Inauguration of KGF Phase-II Nucleon Decay Laboratory (1983)

KGF Phase-II Nucleon decay Experiment 1984-1992



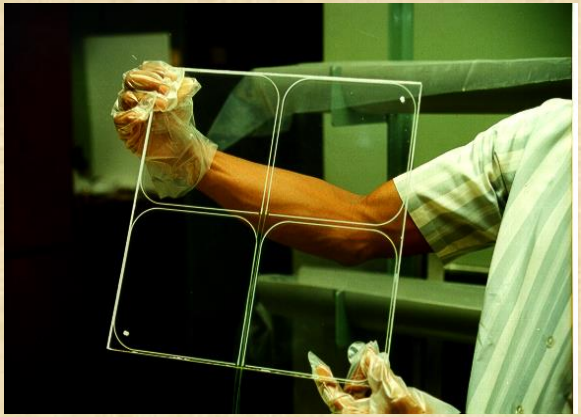
Neutrino Events

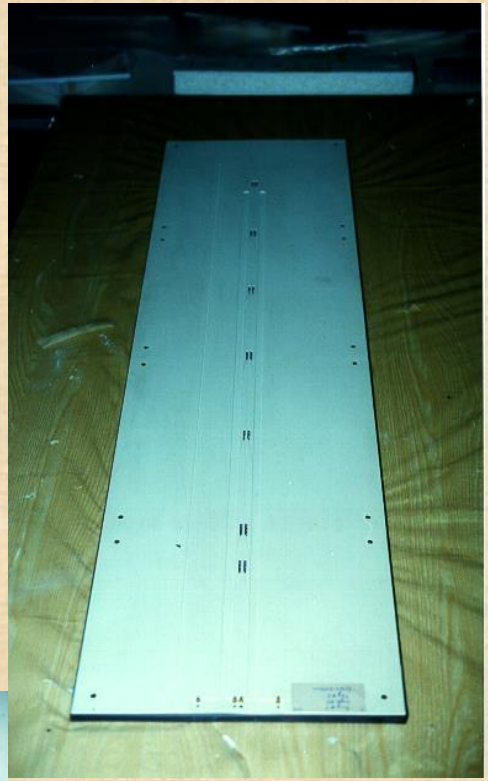


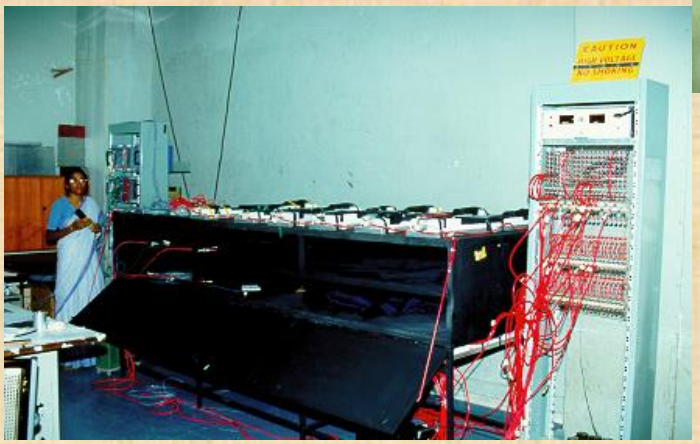


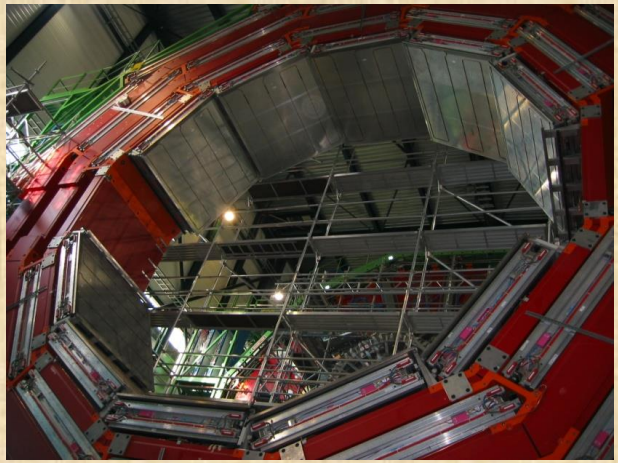
DØ Detector fabrication

CMS Detector Fabrication work

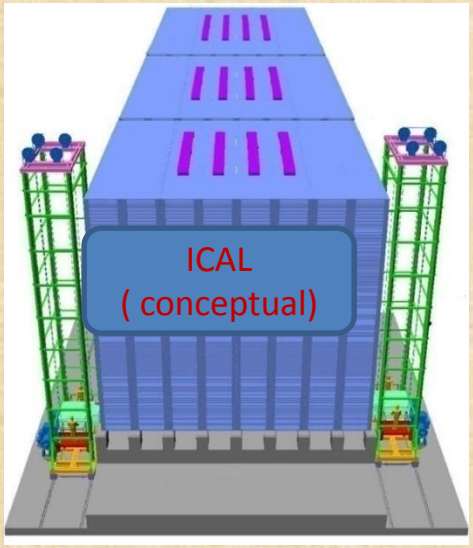


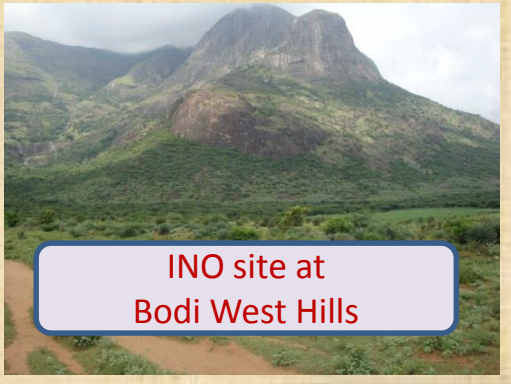


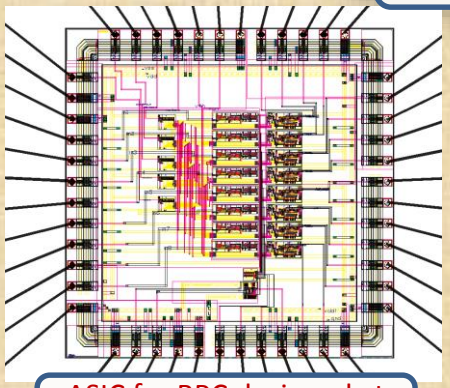




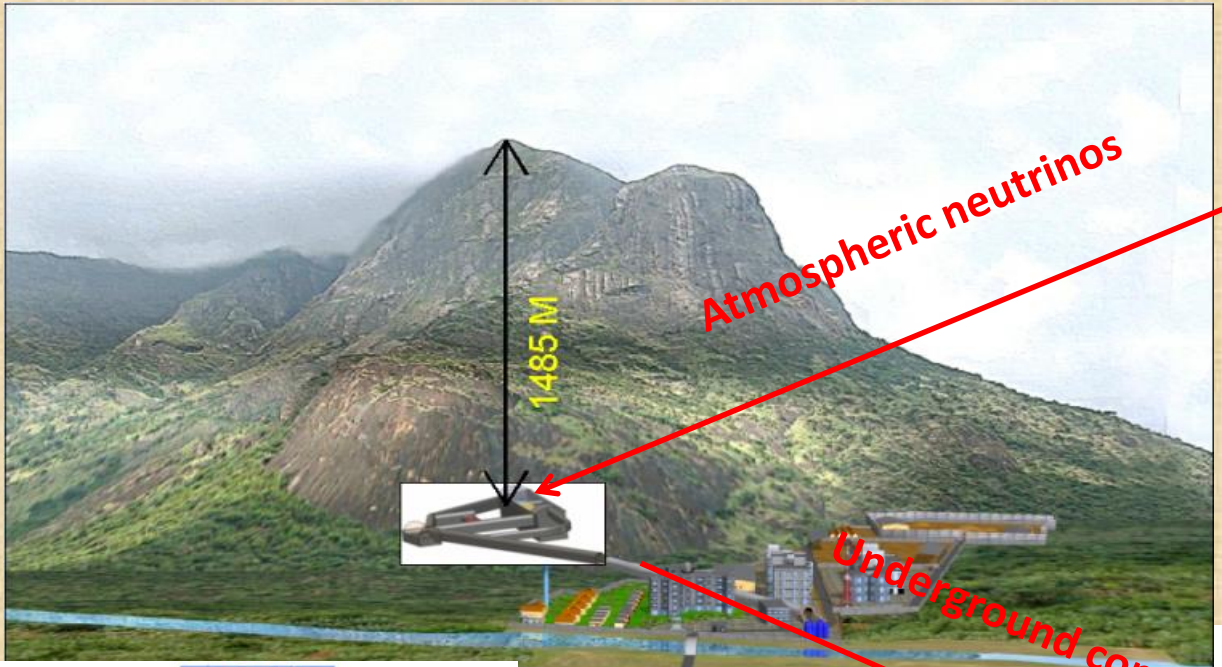
India-Based Neutrino Observatory (INO)

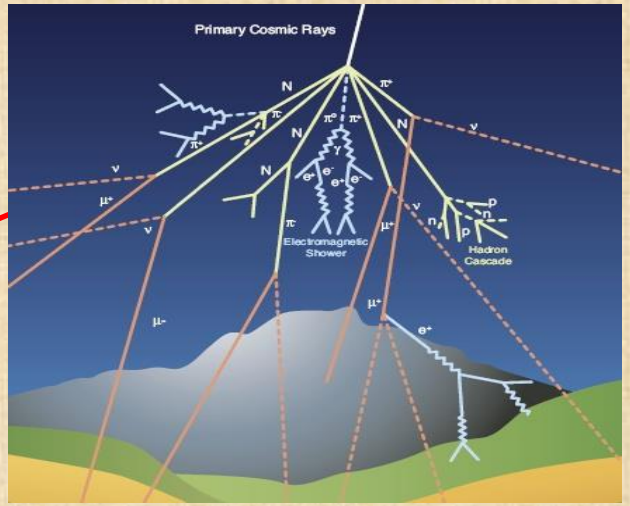


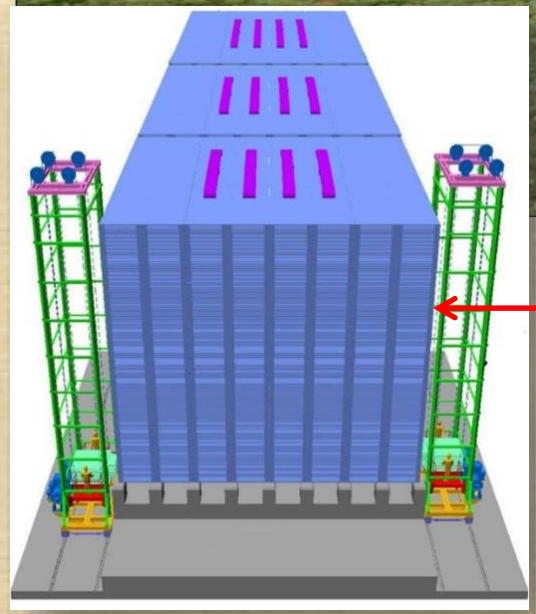


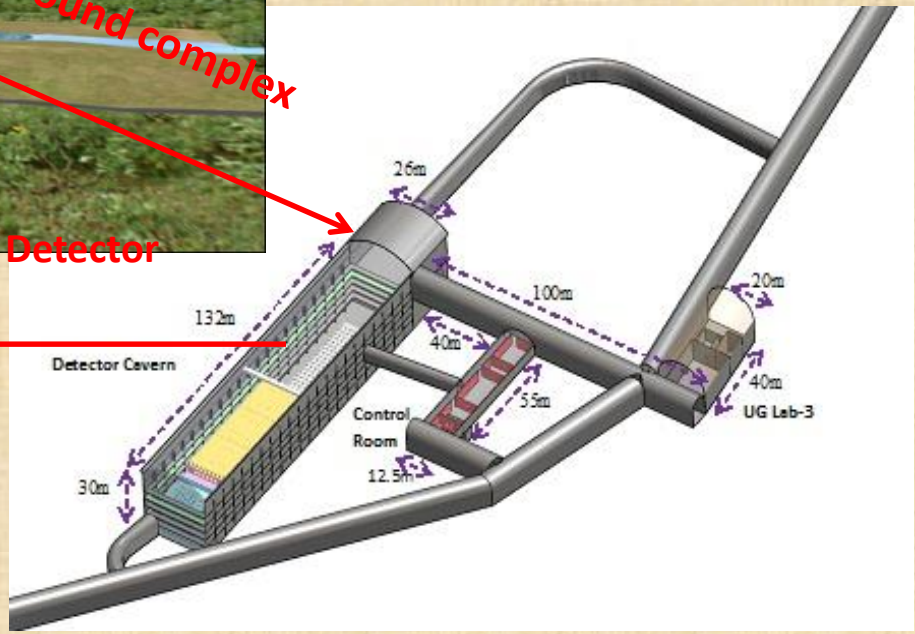


INO site at BodiHills

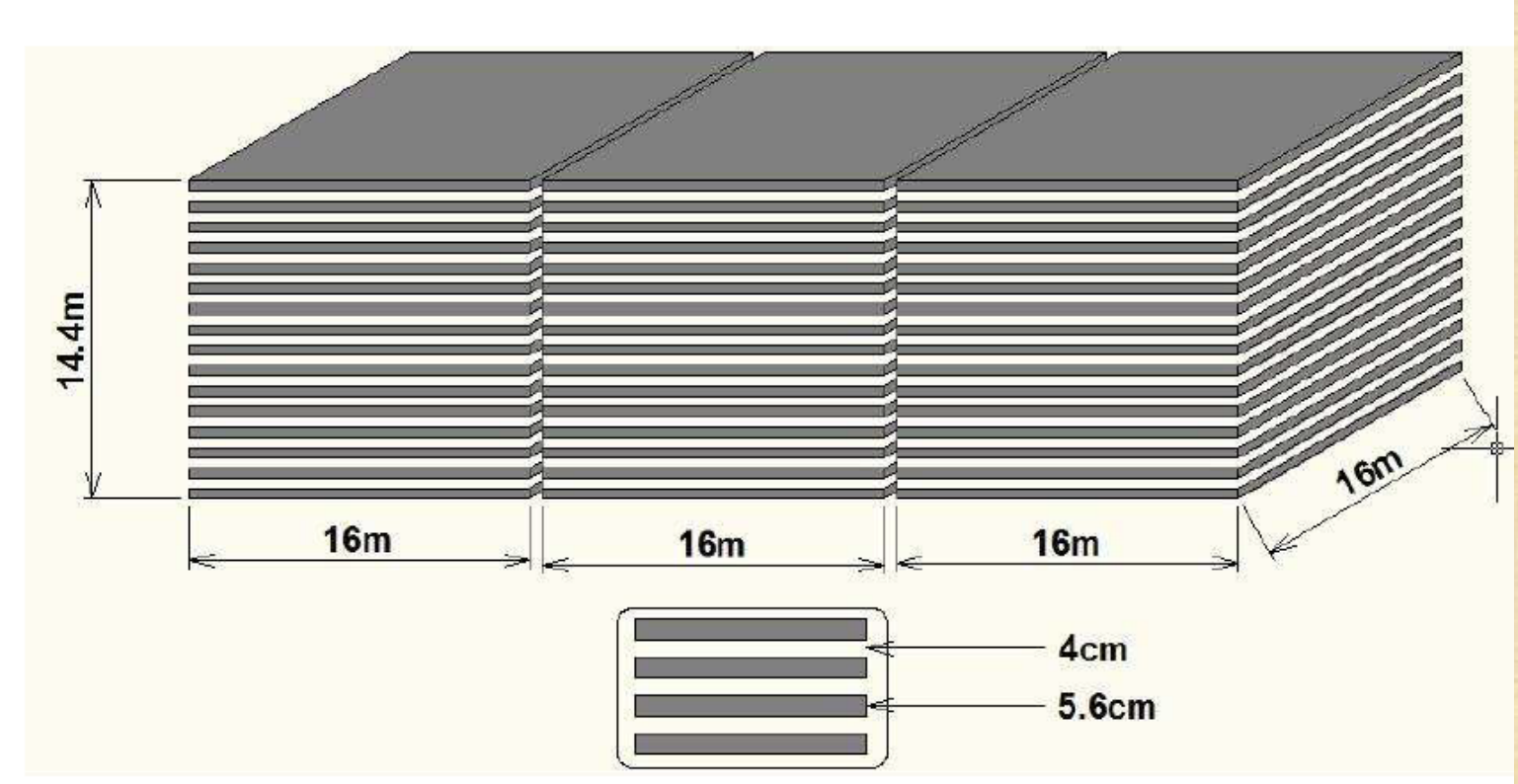




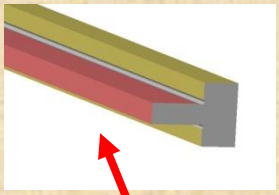




INO-ICAL Detector



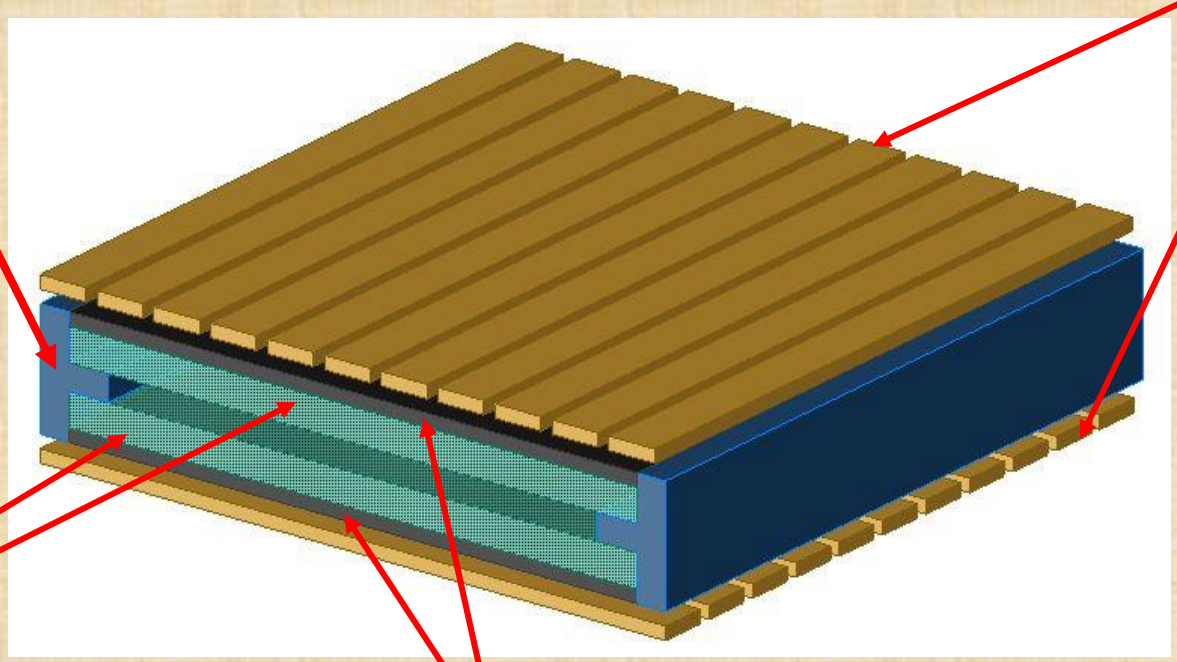
Construction of RPC



Two 2 mm thick float Glass
Separated by 2 mm spacer

2 mm thick spacer

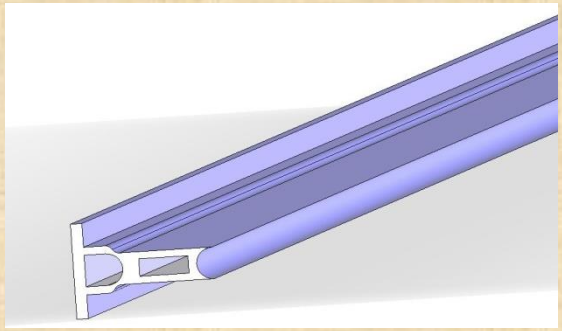
Pickup strips

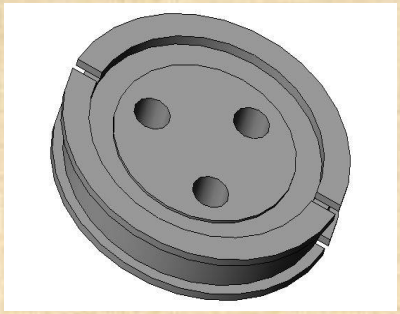


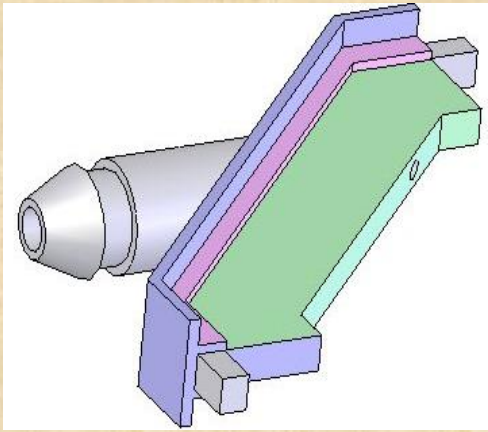
Glass plates

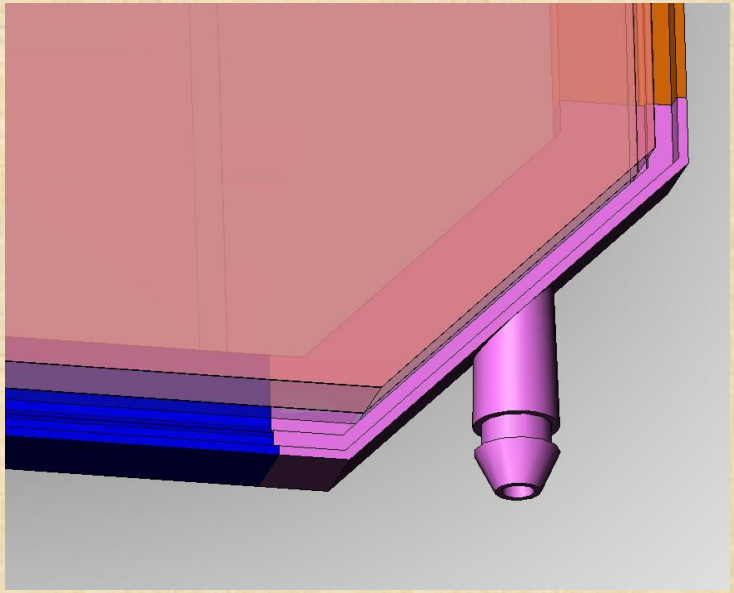
Resistive coating on the outer surfaces of glass

RPC building blocks

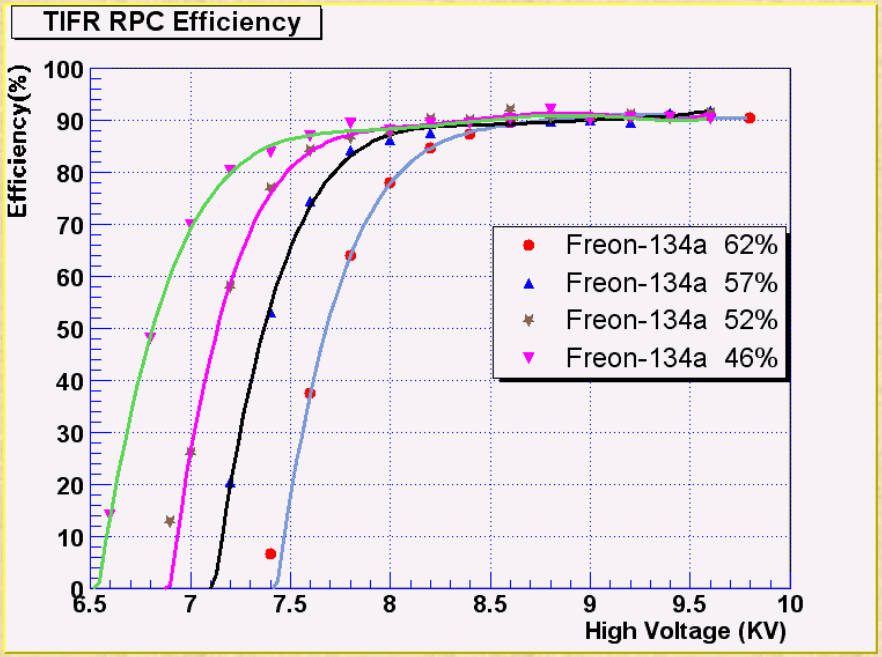


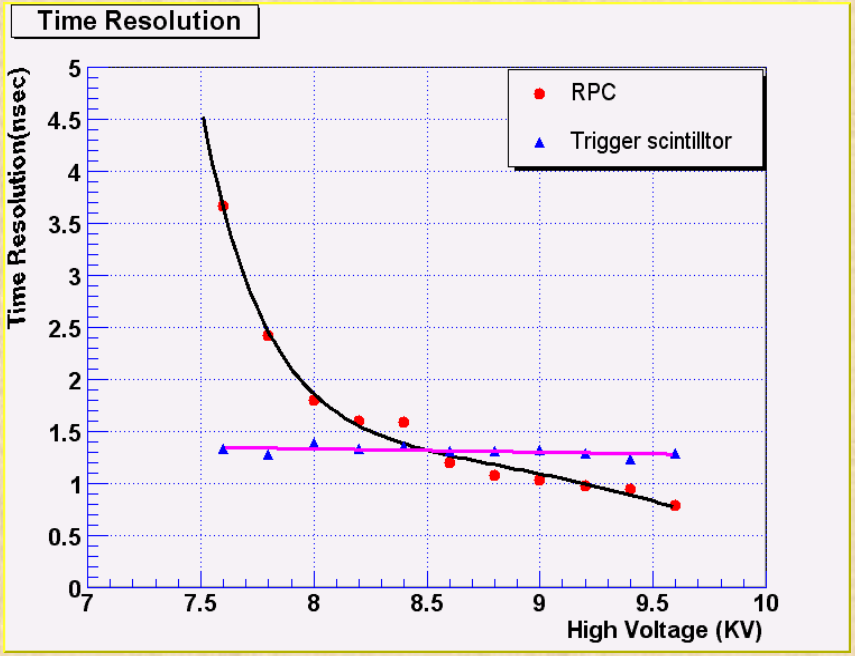






Early results on RPC efficiencies and time resolution

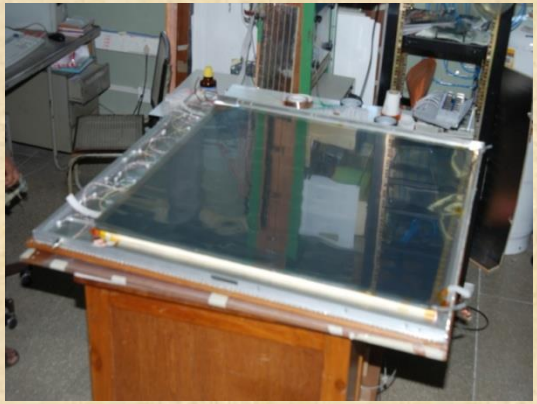


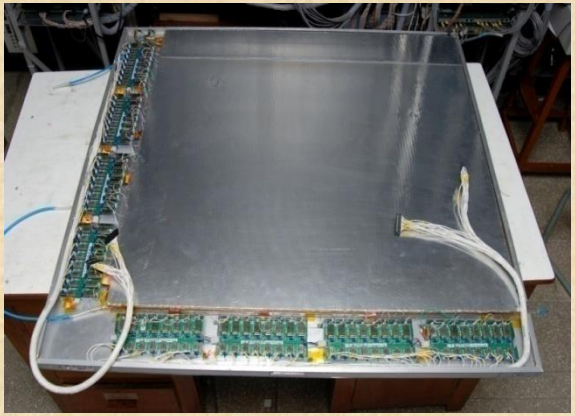


Efficiency

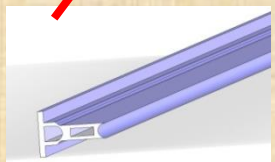
Time resolution

Fabrication of 1m x 1m RPCs





Final RPC Frontier - Making of 2m x 2m RPCs



RPC fabrication at Asahi Float Glass Co.

A journey through RPC road

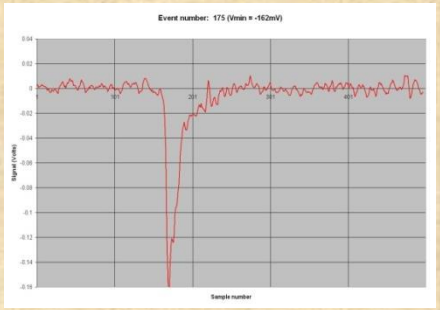
200 cm x 200 cm

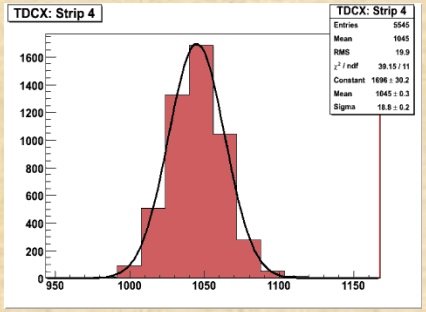
30 cm x 30 cm

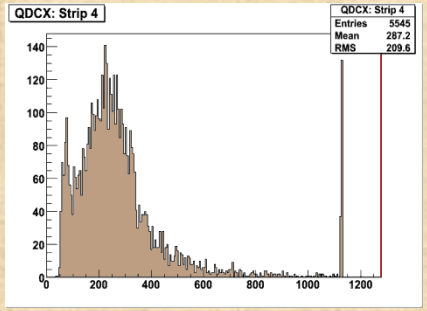
10 cm x 30 cm

100 cm x 100 cm

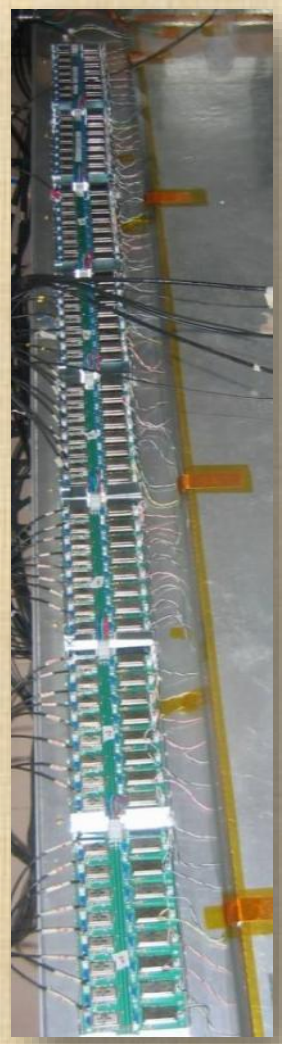
Prototype RPC Stack at TIFR tracking Muons



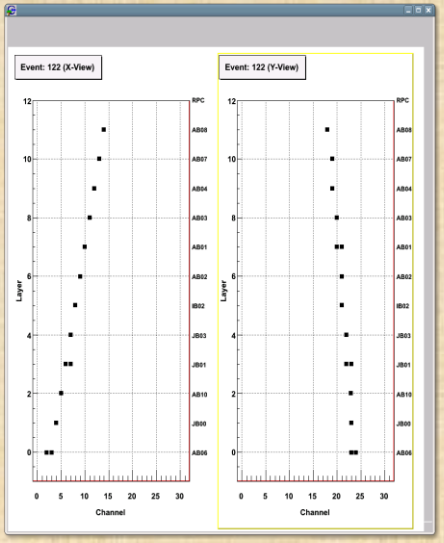


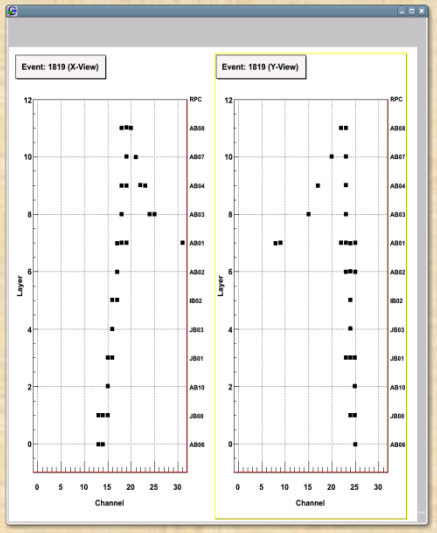


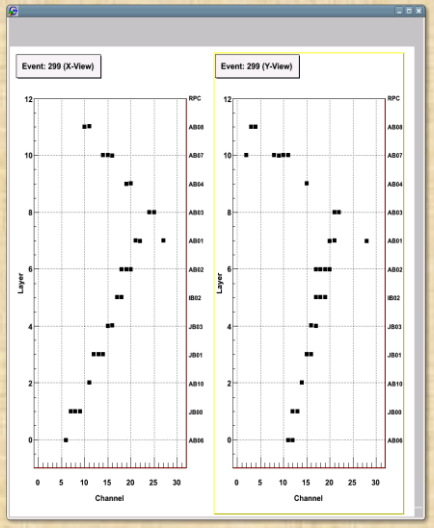
2m x 2m glass RPC test stand

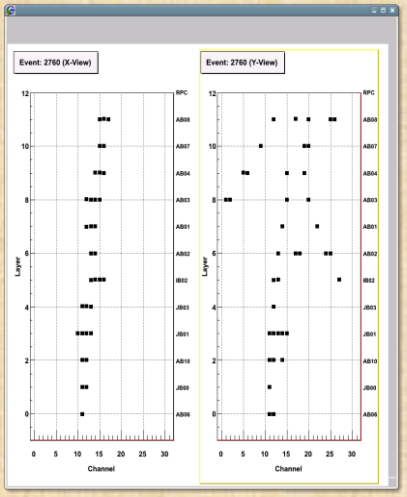


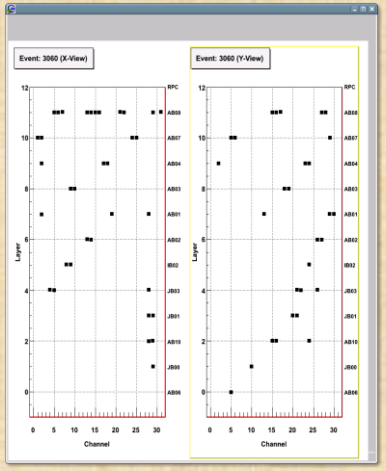
cosmic ray tracks in the RPC stand





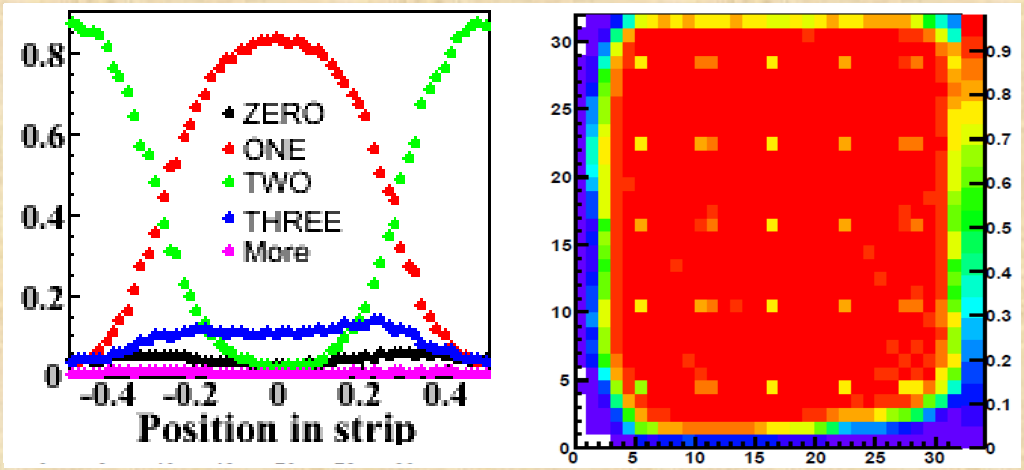




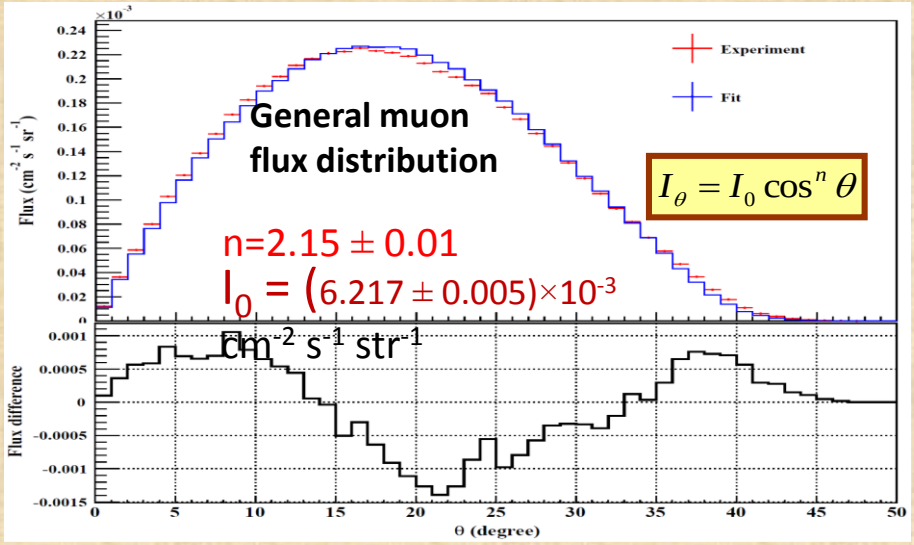


Demonstrate the Tracking Capability of the RPC system

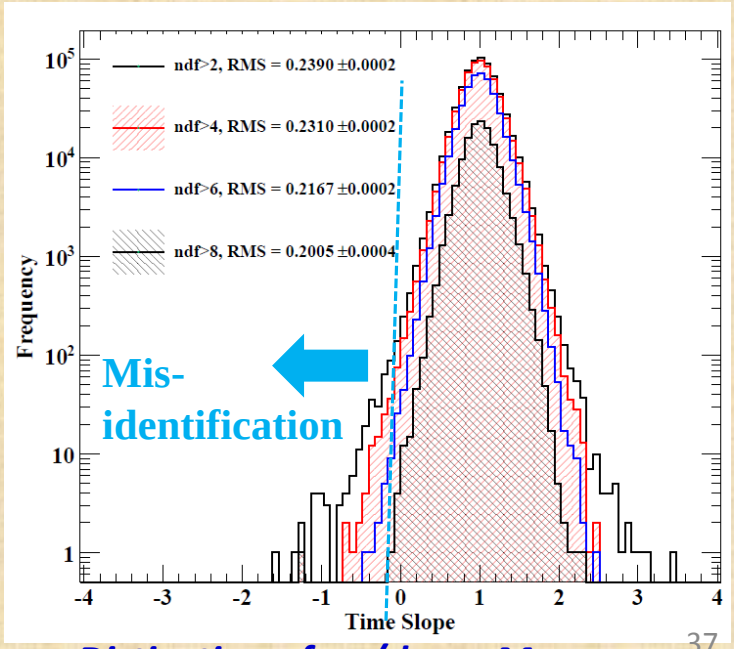
Running Prototype RPC Stack at TIFR



Zenith angle of muon, measurement of cosmic muon flux as well as it angular dependency



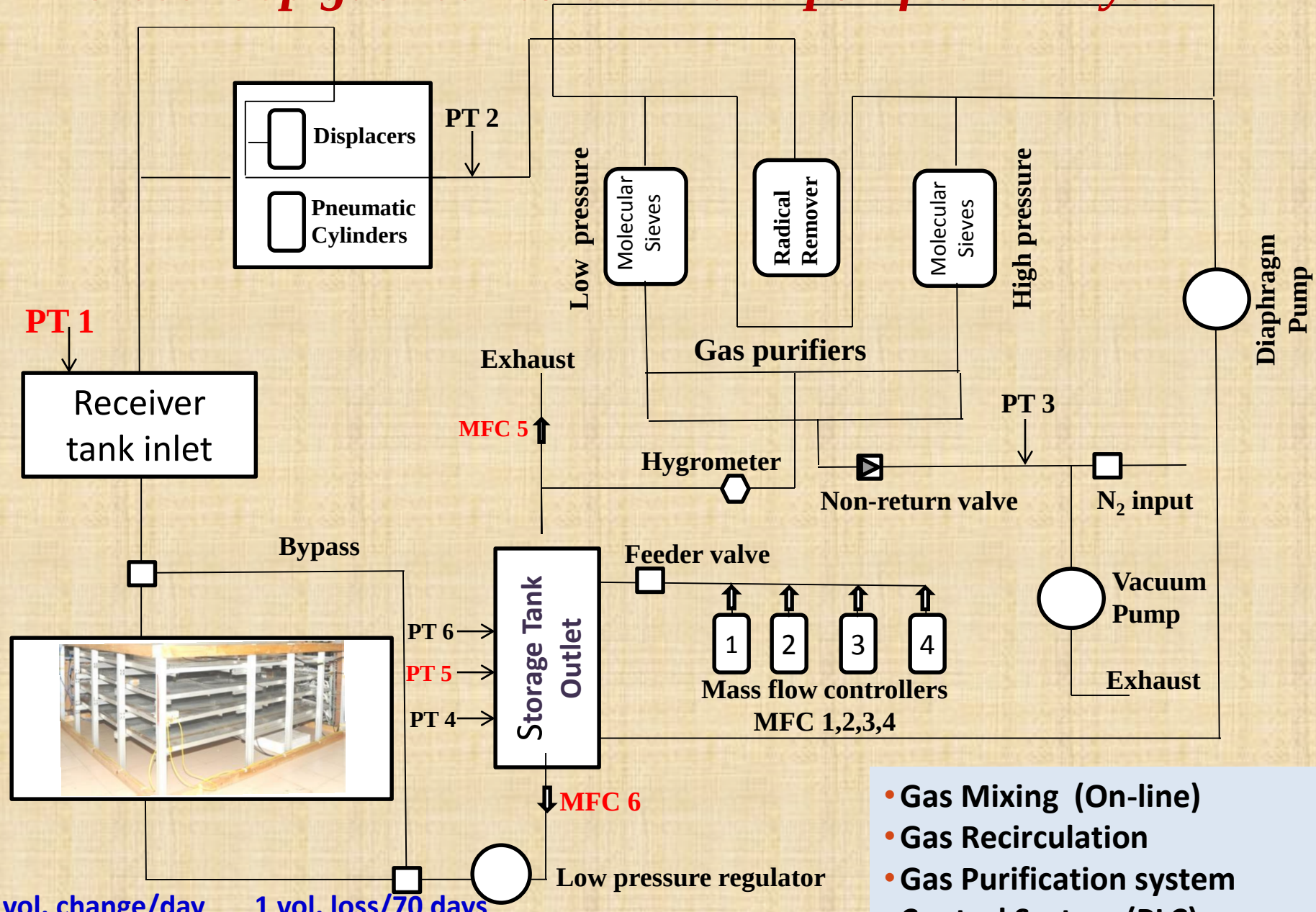
Input to detector simulation and digitisation



Distinction of up/down Muon

Newly developed gas recirculation system

Close loop gas recirculation and purification system

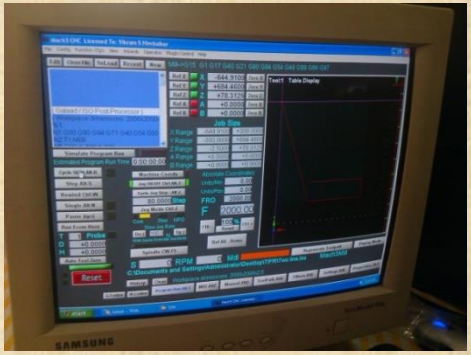


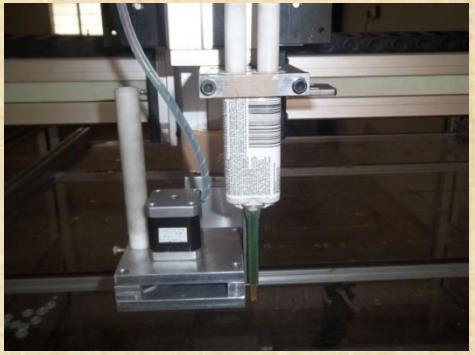
- Gas Mixing (On-line)
- Gas Recirculation
- Gas Purification system
- Control System (PLC)

1 vol. change/day 1 vol. loss/70 days

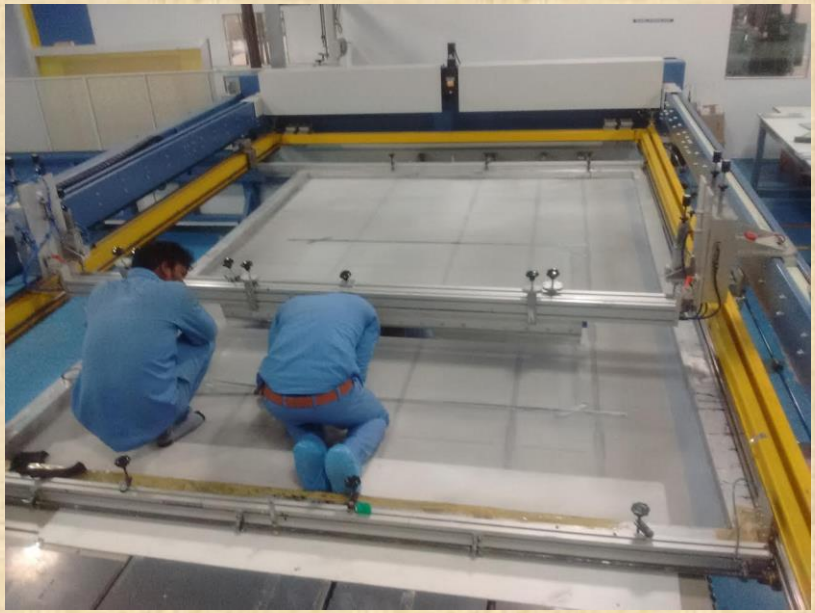
Automated pressure control, 1-3mbar above atm

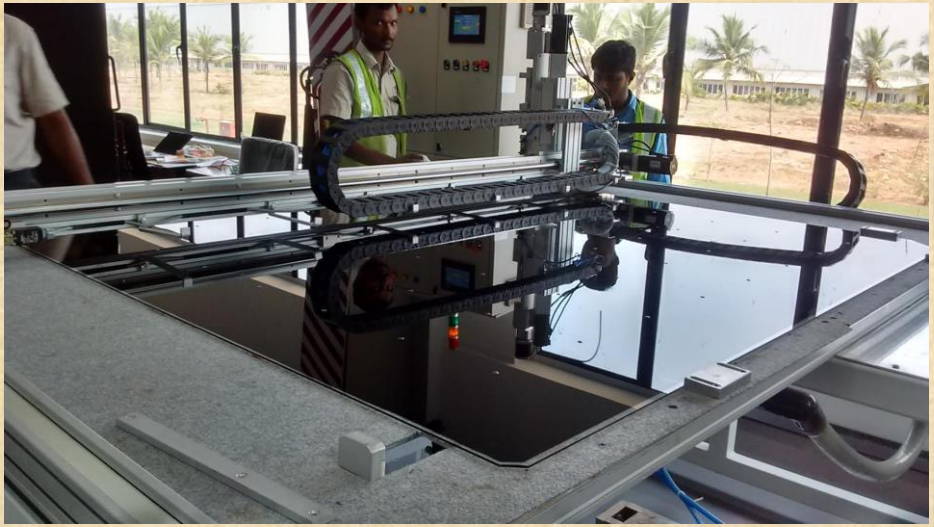
Automatic RPC gap making





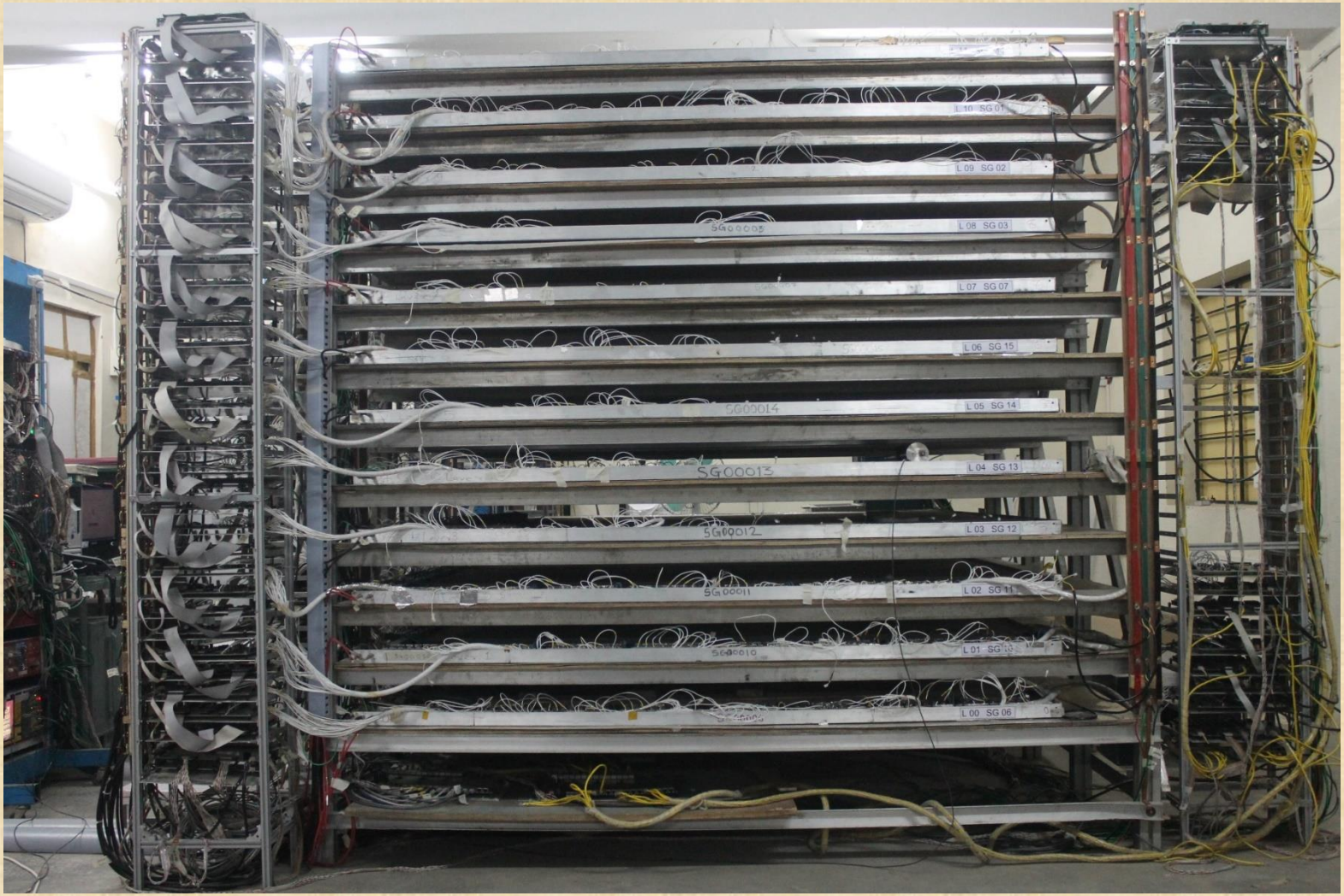
Industrial production of RPC





Running of Prototype RPC Stack at Madurai

Operational since last one year



Publications RPC R & D

List of publications:

- JCAP, 07, 2012, 033
- NIM A678, 105, 2012
- NIM, A694, 126, 2012
- NIM A661,64, 2012
- NIM A661,68, 2012
- NIM A661,73, 2012
- NIM A661,77, 2012
- NIM A661, 234, 2012
- NIM A602, 784, 2009
- NIM A602, 744, 2009
- NIM A 602, 845, 2009
- NIM A 602, 835, 2009
- NIM A 701, 153, 2013
- NIM A 736, 13, 2014
- JINST 11, 2016