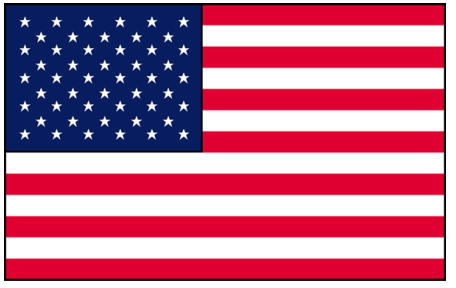
Detector & Electronincs R&D

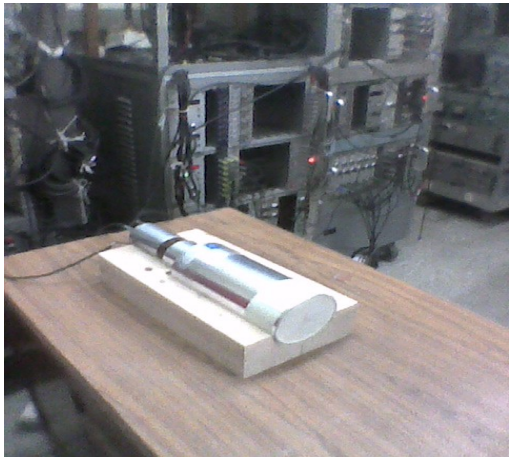
Project-X Working Group Meeting

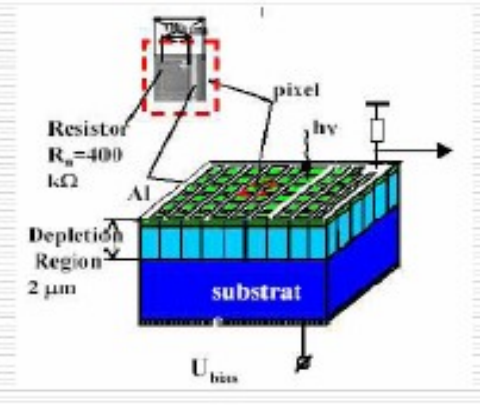
IUAC, New Delhi, 18 June 2011



Sunil K. Gupta

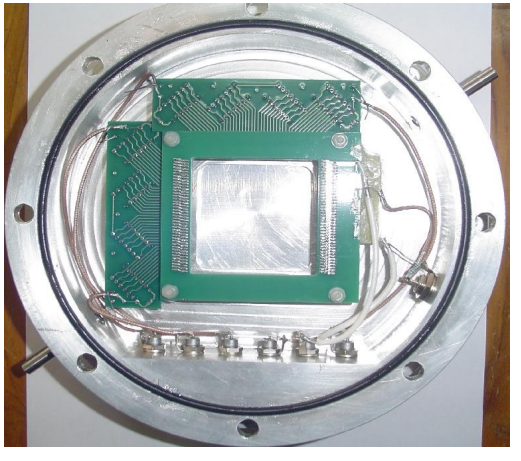
Tata Institute of Fundamental Research, Mumbai

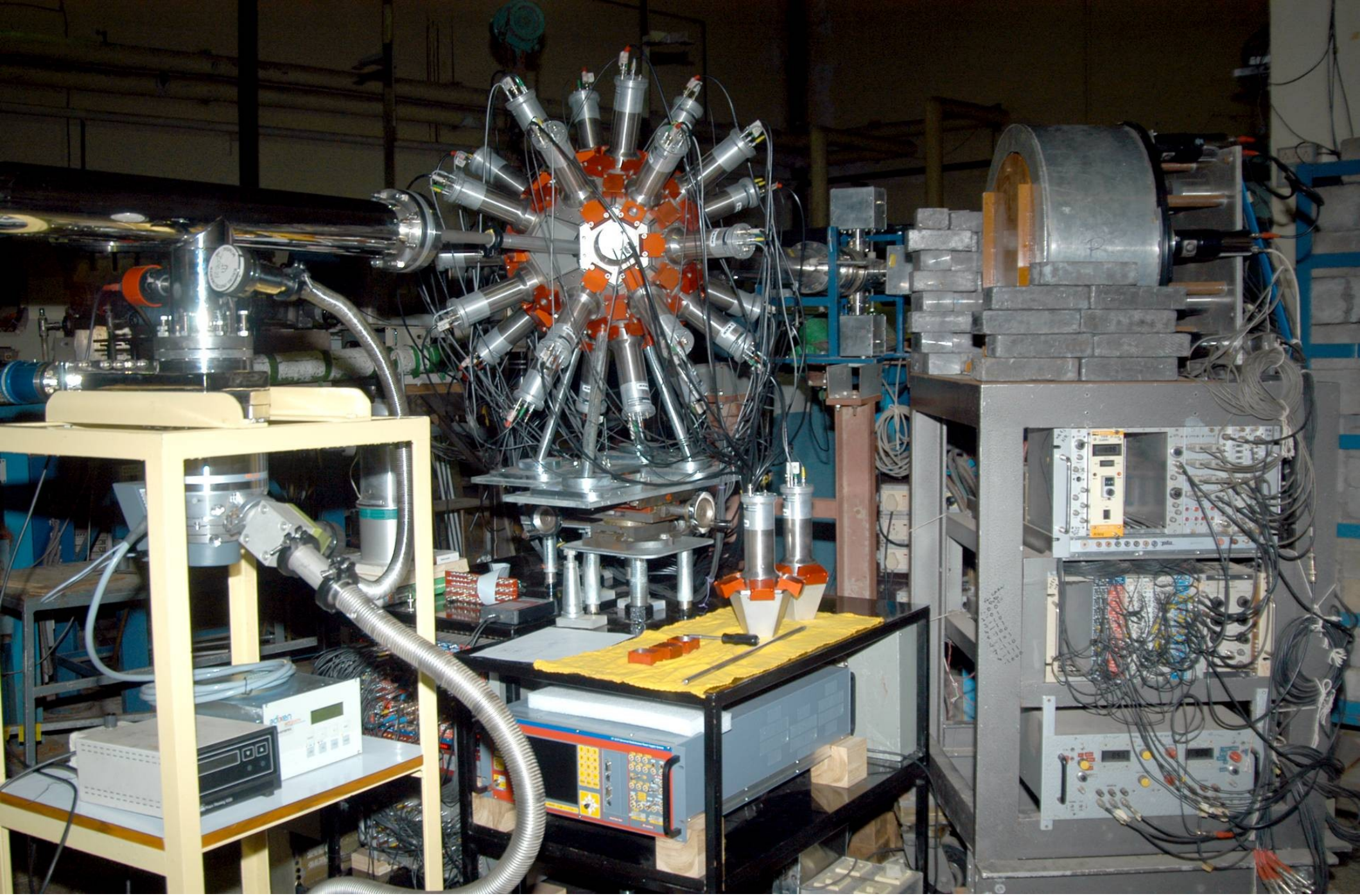




1. Gaseous
2. Scintillator
3. Semiconductor

1. Linear
2. Trigger
3. Signal Processing

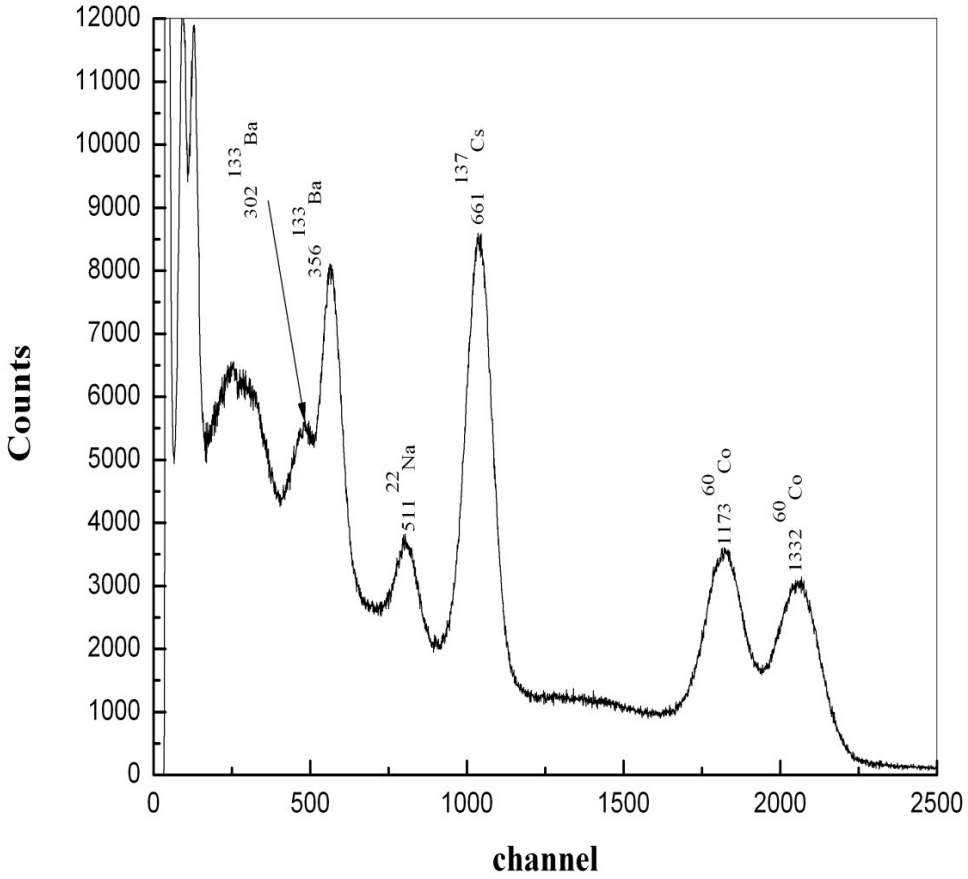




Indranil Mazumdar & Co-workers Nucl. Instrum. Methods A **611** (2009) 76

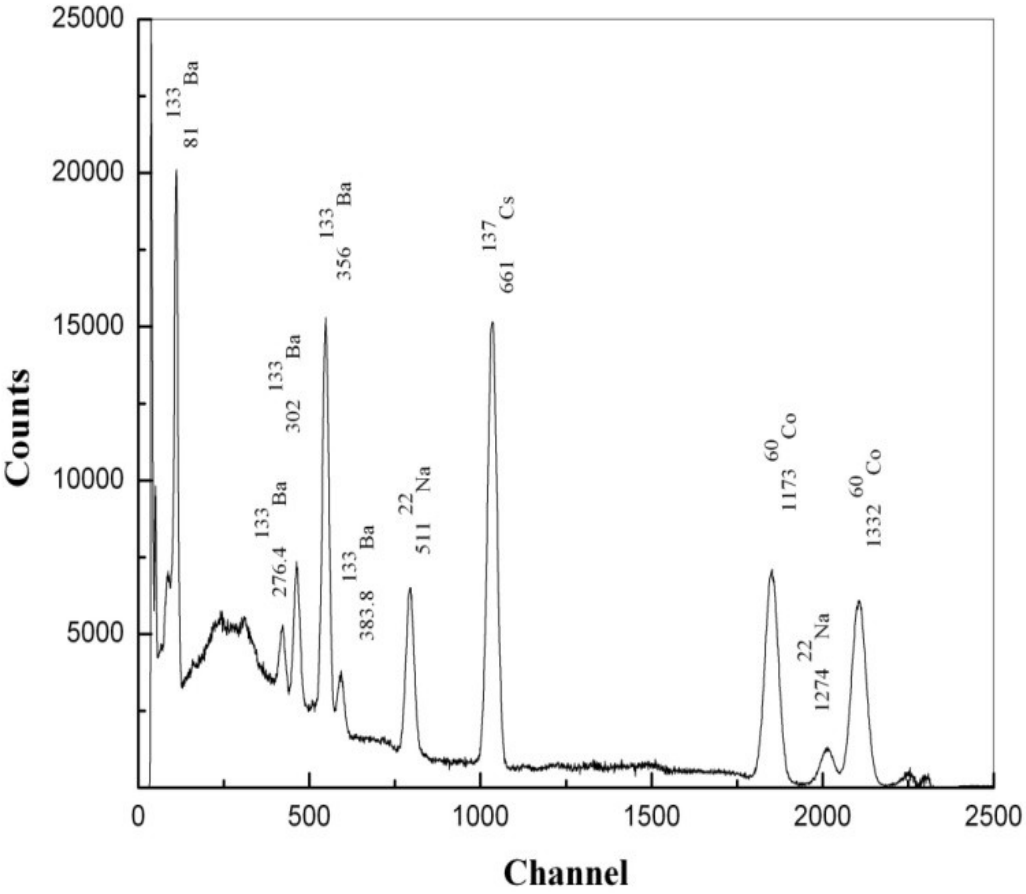
NaI(Tl)

Resolution: 7.5% @661.6 keV



$LaBr_3$:Ce

Resolution: < 3% @661.6 keV

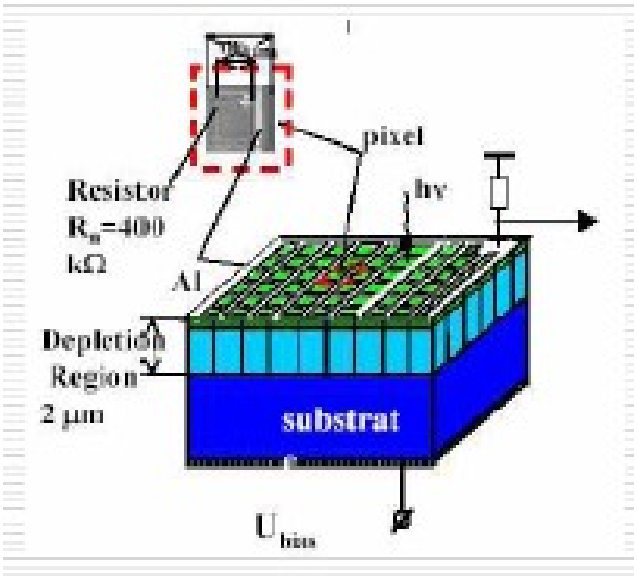


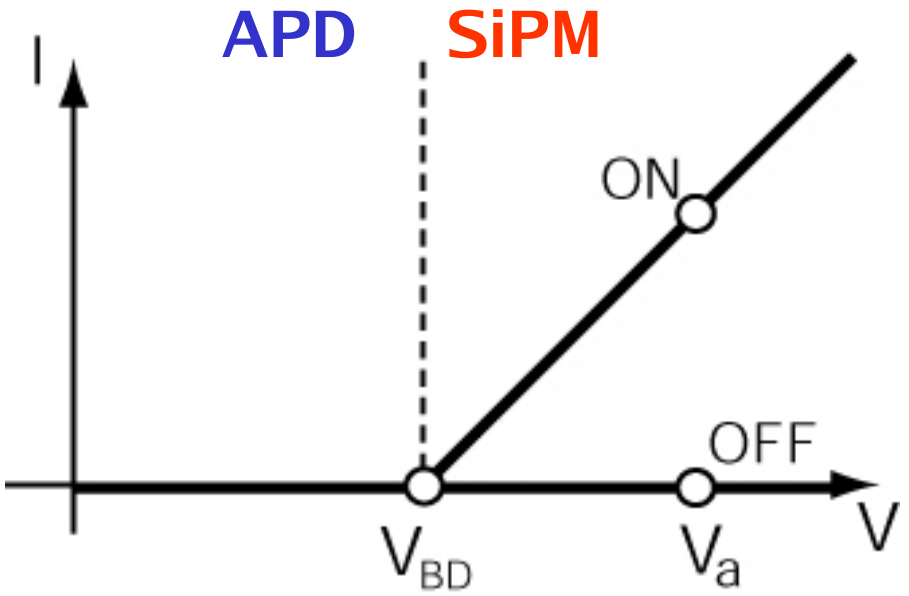
Note:

- Diifferences in energy resolutions
- Differences in p/v ratios
- New peaks in LaBr spectrum

Silicon Photomultiplier

- APD operated above breakdown voltage
  - Geiger response mode
- Essentially a logical device
  - Photon counting by an array of diodes in small area

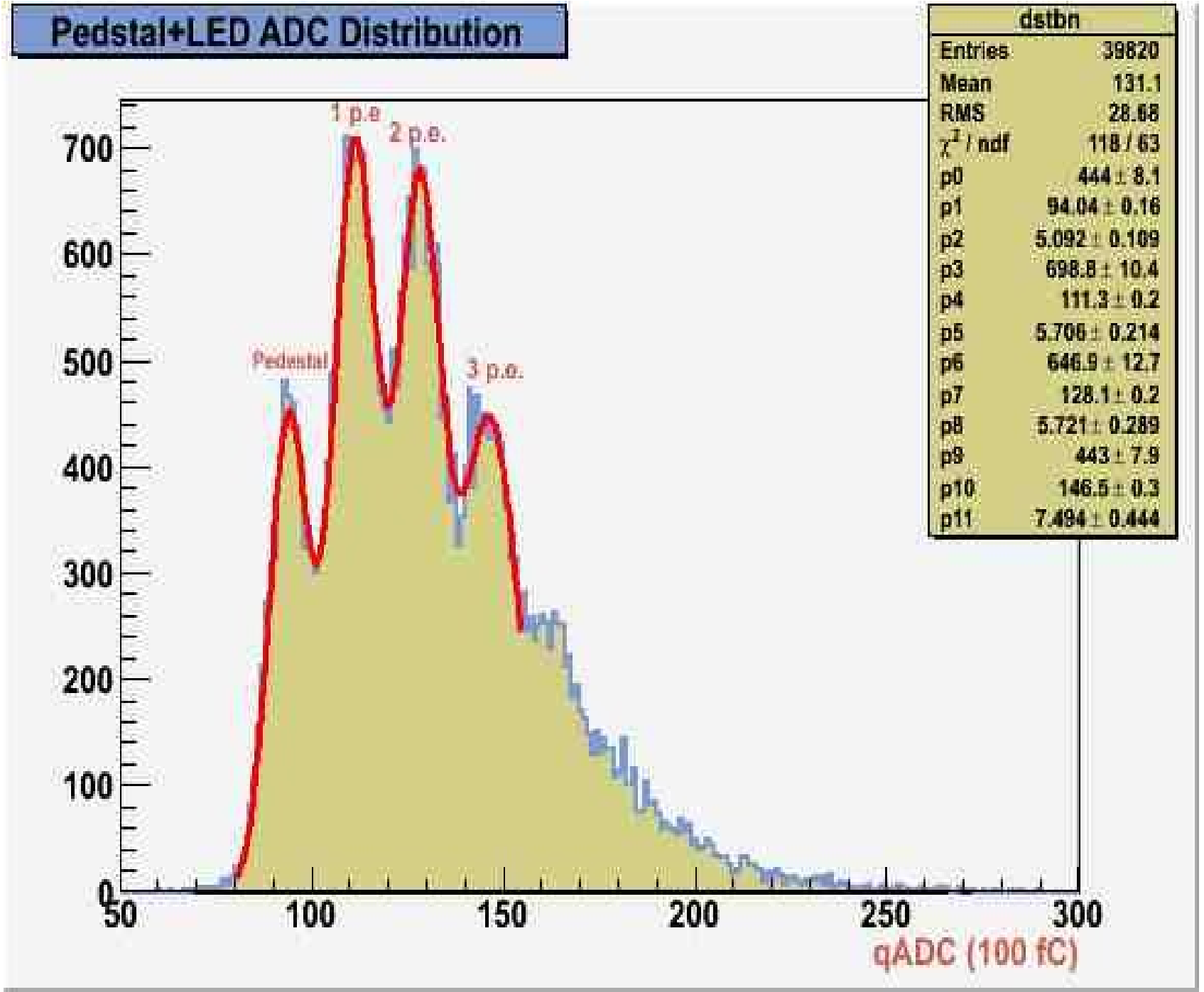


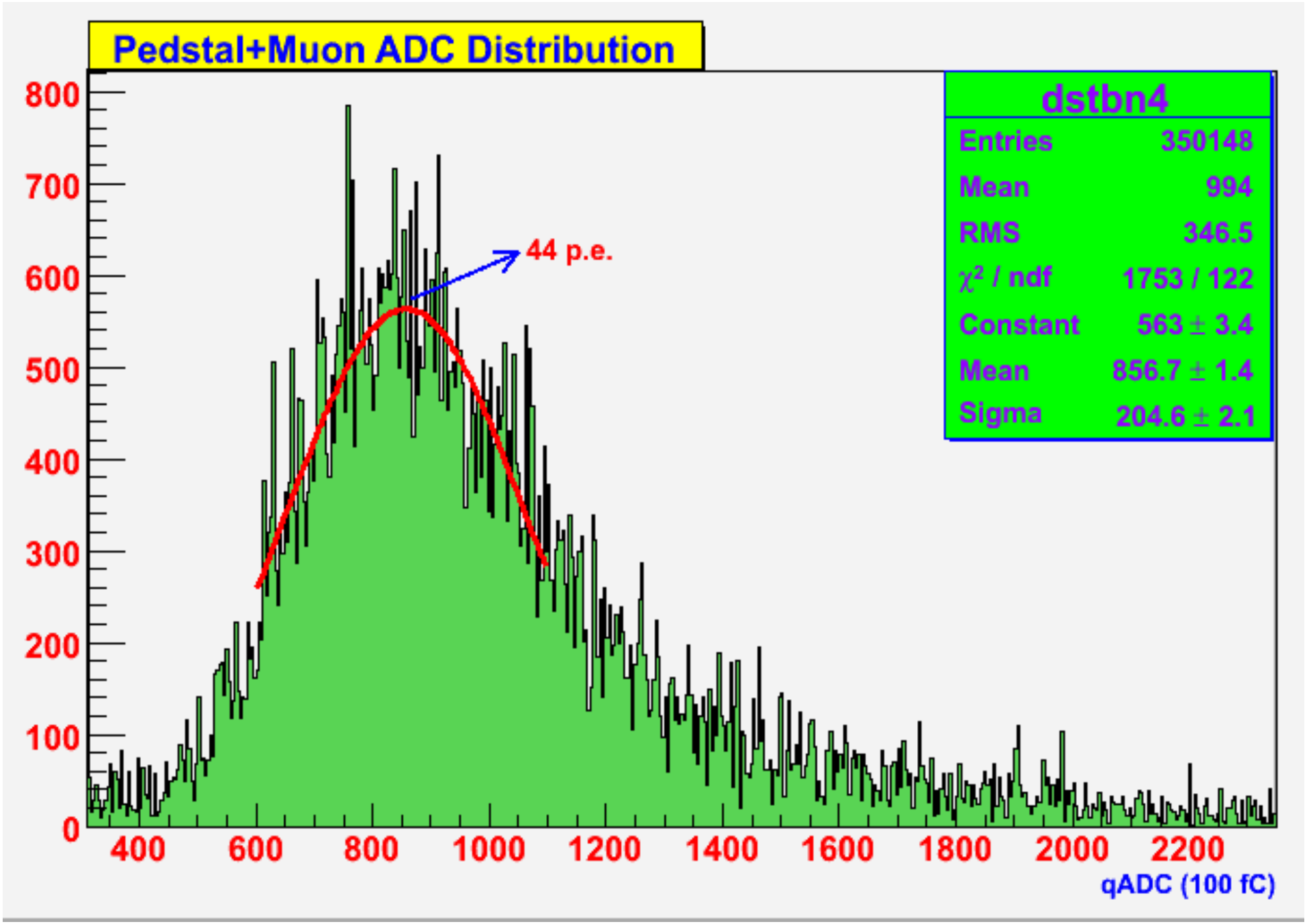


Silicon Photomultiplier Development

- SiPM characterization facility at GRAPES-3 in Ooty
  - Setup for V-I characteristic, single pixel calibration, linearity, MIP sensitivity etc.
  - Micron resolution optical scanner for studying pixel-to-pixel response to be developed soon at TIFR, Mumbai
- Packaging and assembly of the device
  - For bare SiPMs from HCAL-CMS at BEL, Bangalore
- Device and Process Simulation
  - Under progress
- Fabrication
  - BEL, Banglore
  - Semiconductor Complex Limited, Chandigarh
  - 1st Prototyping Run anticipated in 2011-2012

SiPM Response using LED at Ooty




Pedstal+Muon ADC Distribution
dstbn4
Entries 350148
Mean 994
RMS 346.5
χ² / ndf 1753 / 122
Constant 563 ± 3.4
Mean 856.7 ± 1.4
Sigma 204.6 ± 2.1
44 p.e.
800
700
600
500
400
300
200
100
0
400
600
800
1000
1200
1400
1600
1800
2000
2200
qADC (100 fC)

GRAPES-3 Experiment Ooty (11.4N, 76.7E, 2200m)

400 Scintillator detectors (1 m^2 area)

560 m^2 muon detector (E_μ=1 GeV)

Objective: Universe at high energies

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

1. Acceleration of particles in atmospheric electric field
   Energy ~100 MeV Scale ~10^5-10^6 cm

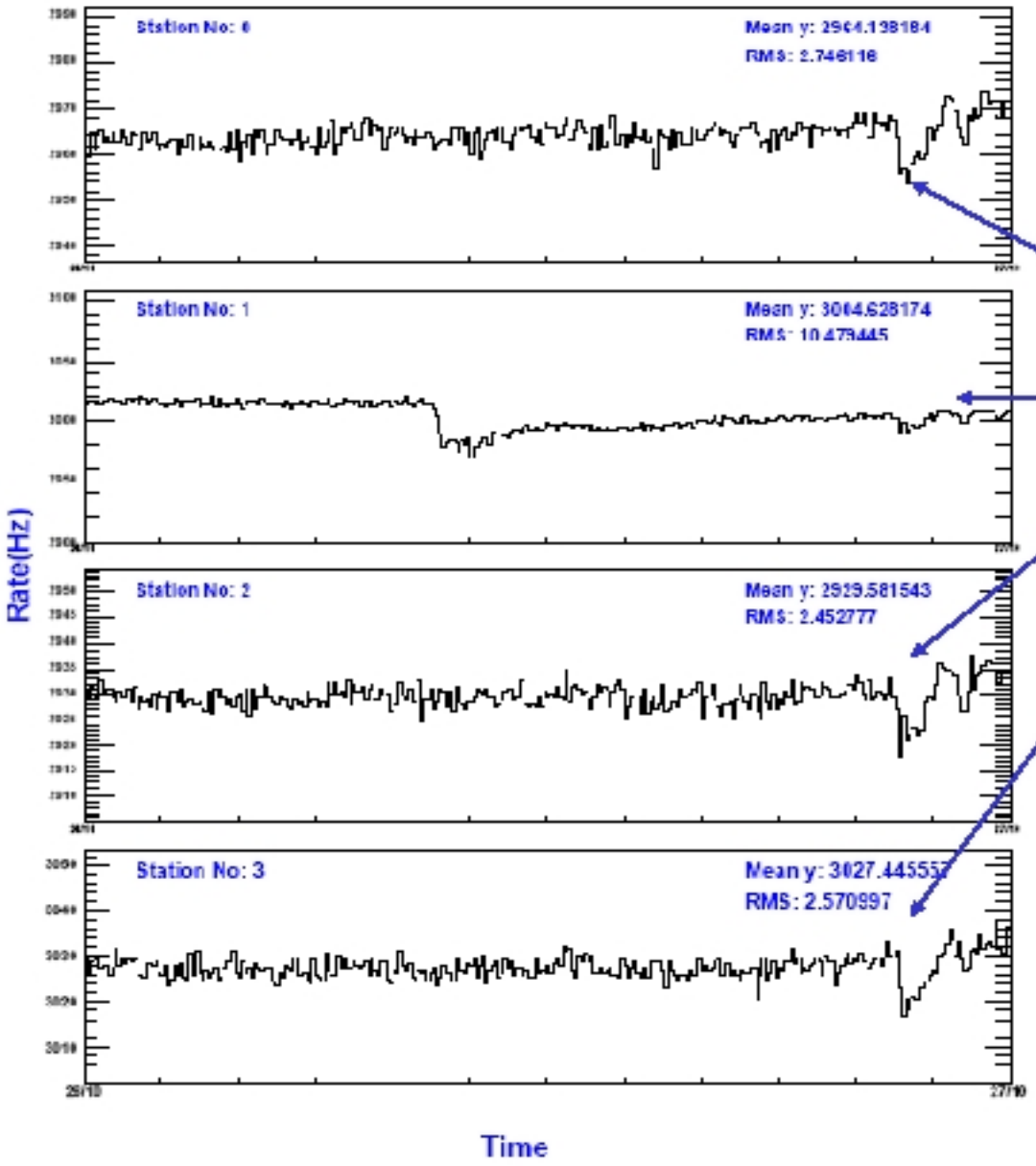
2. Solar flares, Coronal Mass Ejections
   Energy ~10 GeV Scale ~10^{11}-10^{13} cm

3. Galactic Cosmic Rays at " Knee "
   Energy ~1 PeV Scale ~10^{21}-10^{23} cm

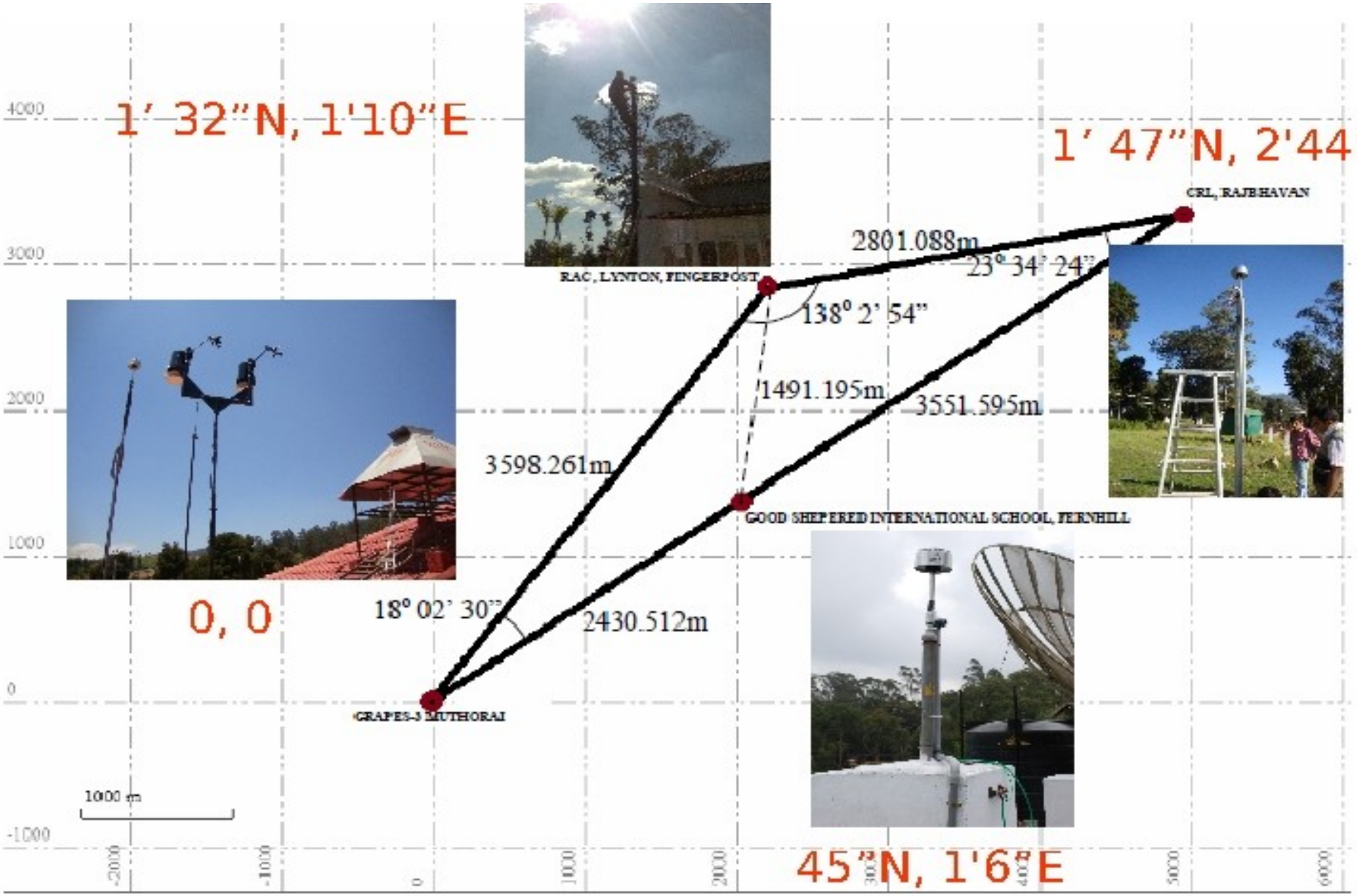
4. Diffuse multi-TeV γ-rays
   Energy ~100 EeV Scale ~10^{24}-10^{26} cm

Thunderstorm Event

Energy ~100 MeV
Scale ~10^5-10^6 cm



Decrease in muon rate at shorter time scale



GRAPES-3 Lat. = 11° 23’ 26” N Long. = 76° 39’ 50” E

Fabrication of Plastic Scintillator

Plastic Scintillator development:

Decay Time= 1.6 ns

Output = 54% Anthracene

Timing 25% faster

Atten. Length λ= 100 cm

Low Cost

Max Size 100 cmX100 cm

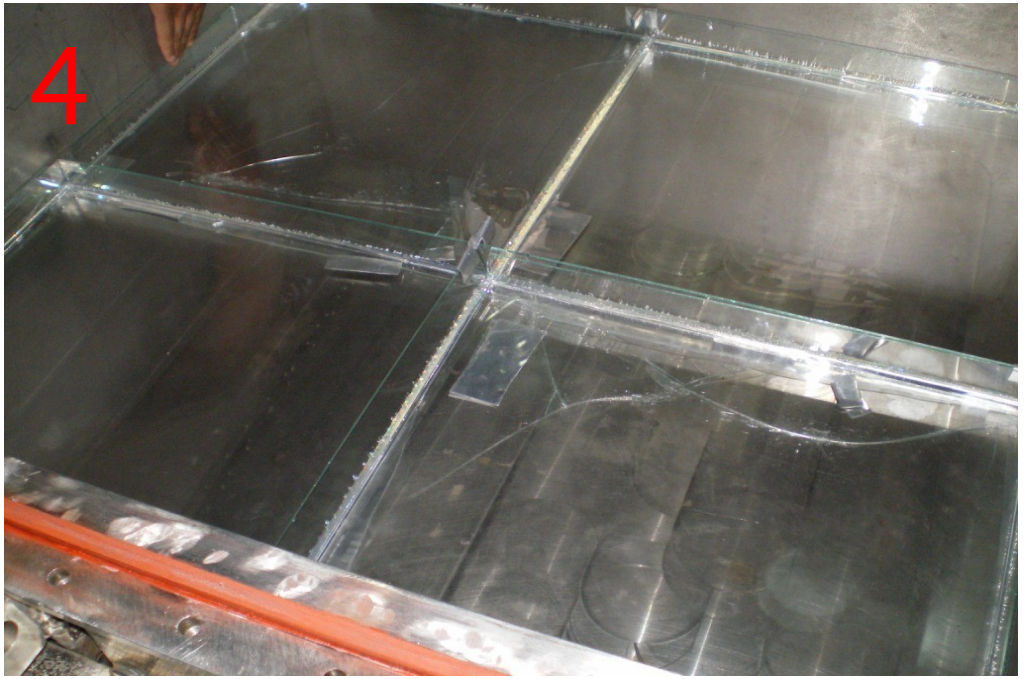
Total > 2000

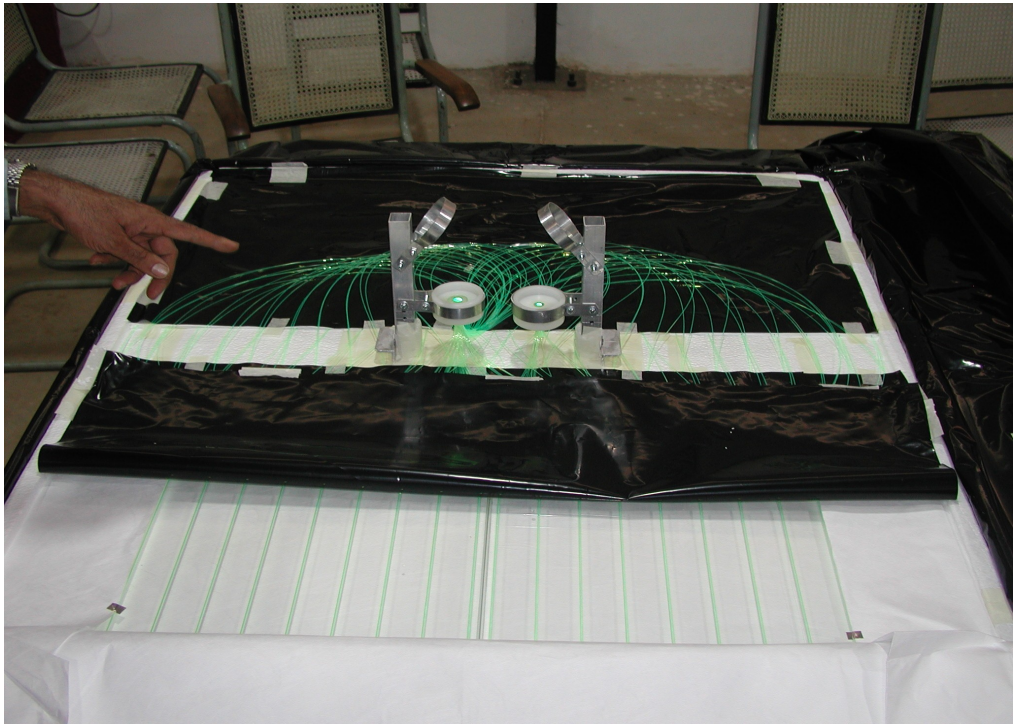
TIFR, CERN, Osaka, IUAC Delhi, Bose, VECC, etc.

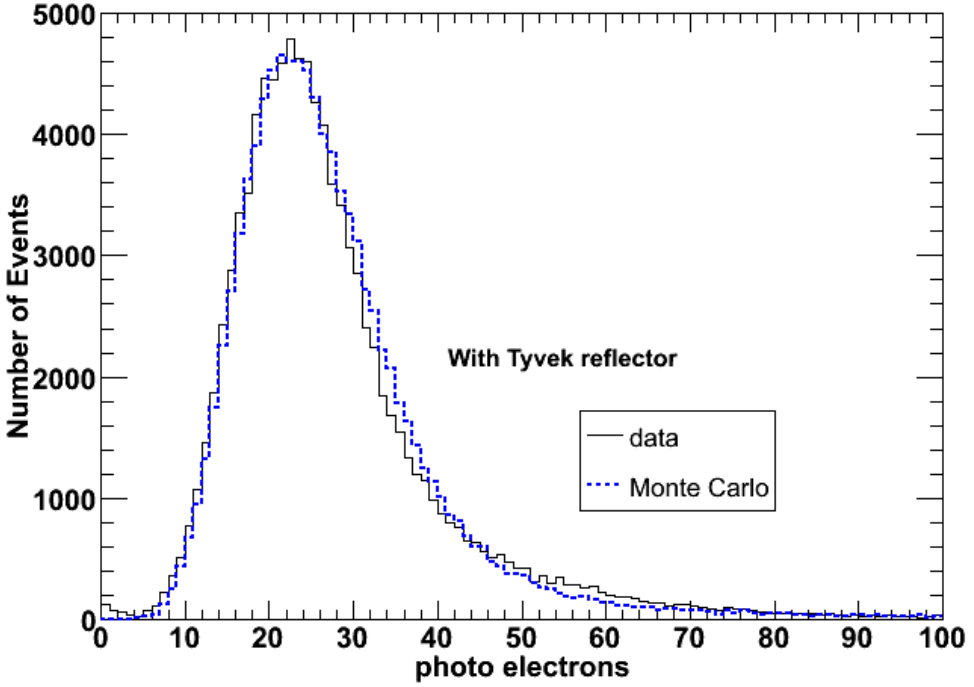

1

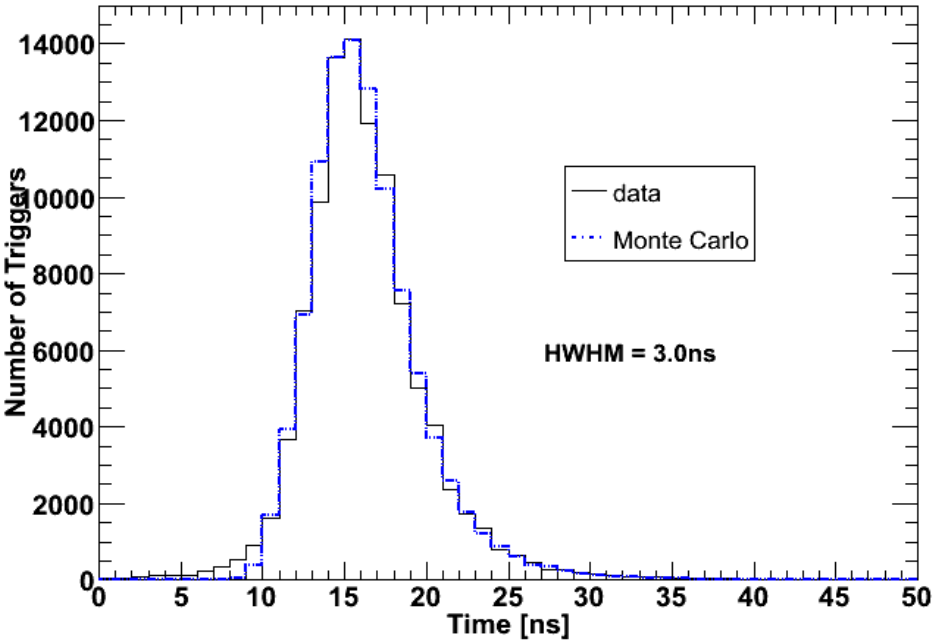

2

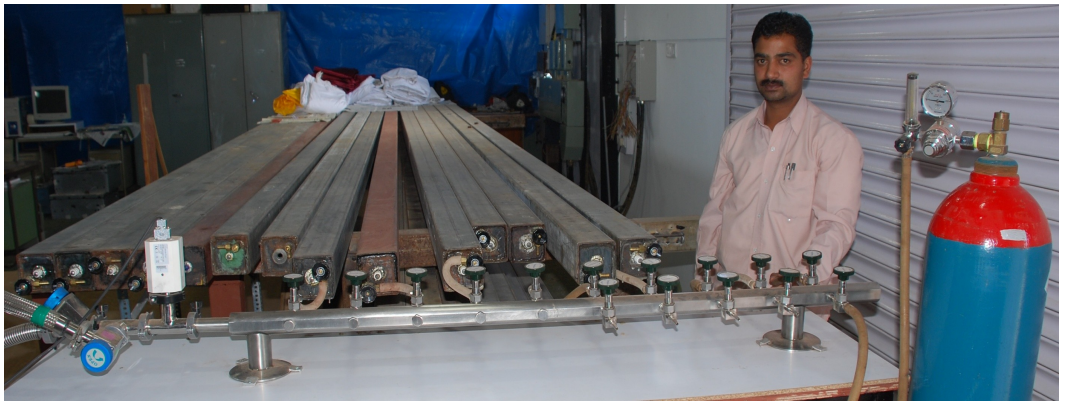

3

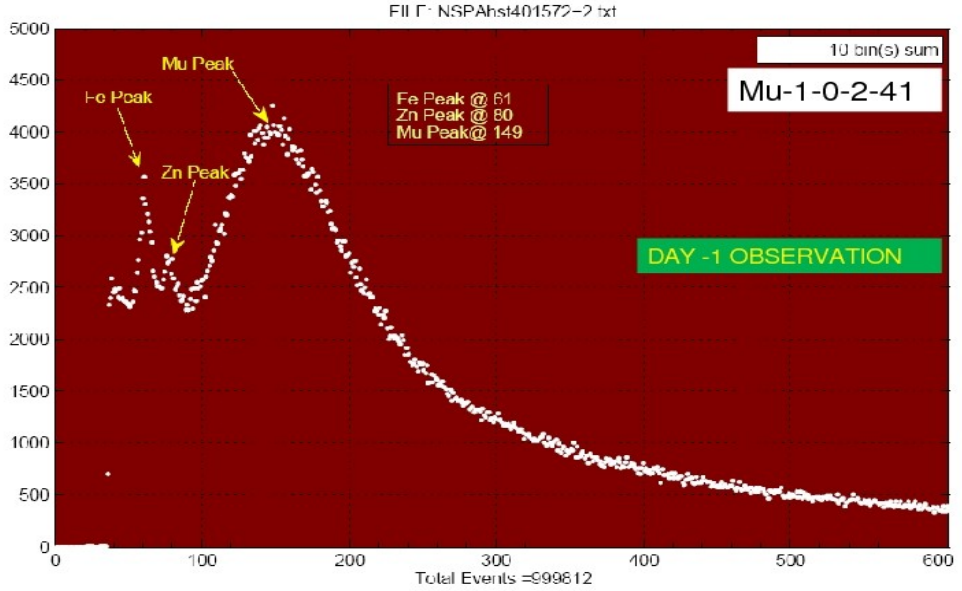

4




Number of Events
photo electrons
With Tyvek reflector
data
Monte Carlo


Number of Triggers
Time [ns]
data
Monte Carlo
HWHM = 3.0ns





Proportional Counter Test Setup

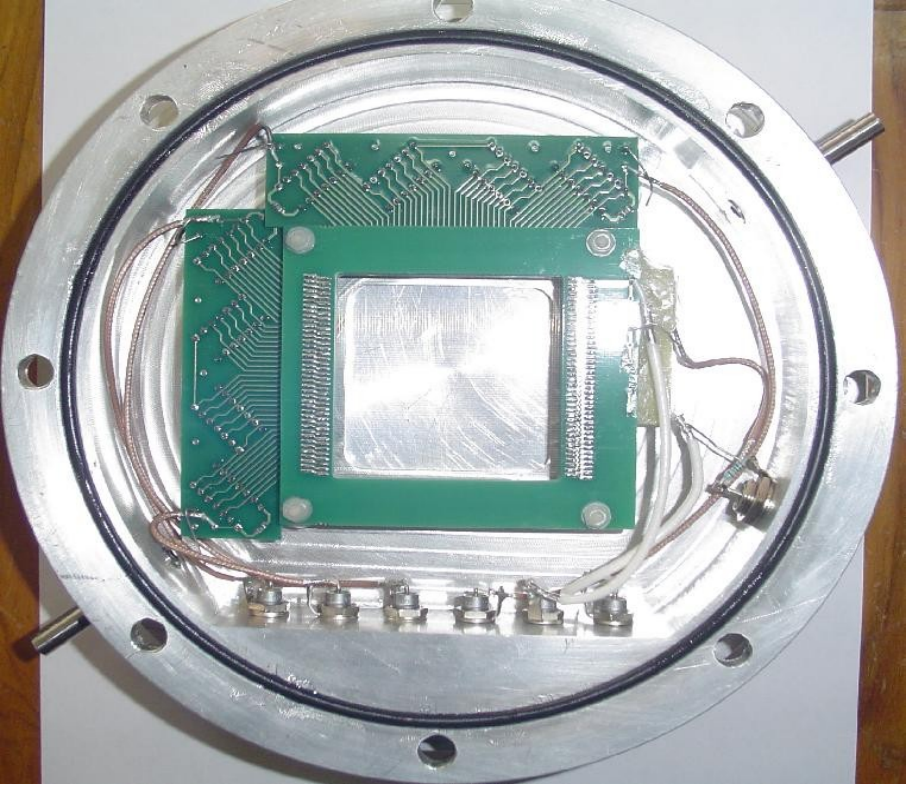
MWPC development at IUAC, New Delhi

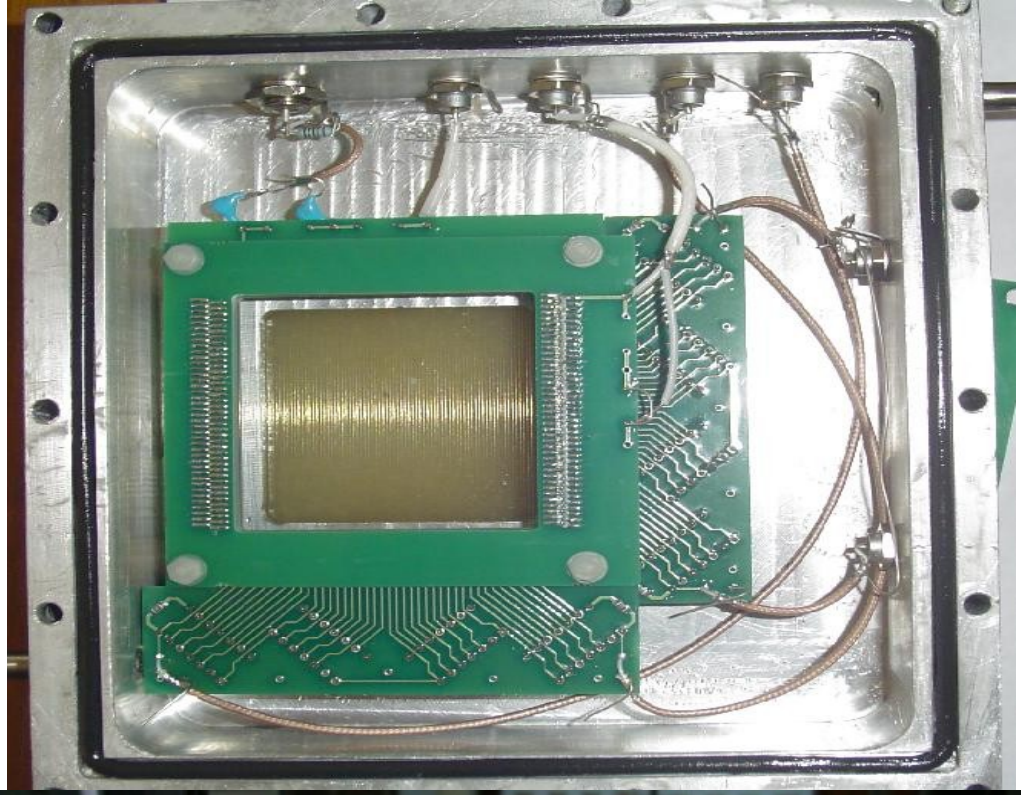
TOF System for fission experiments

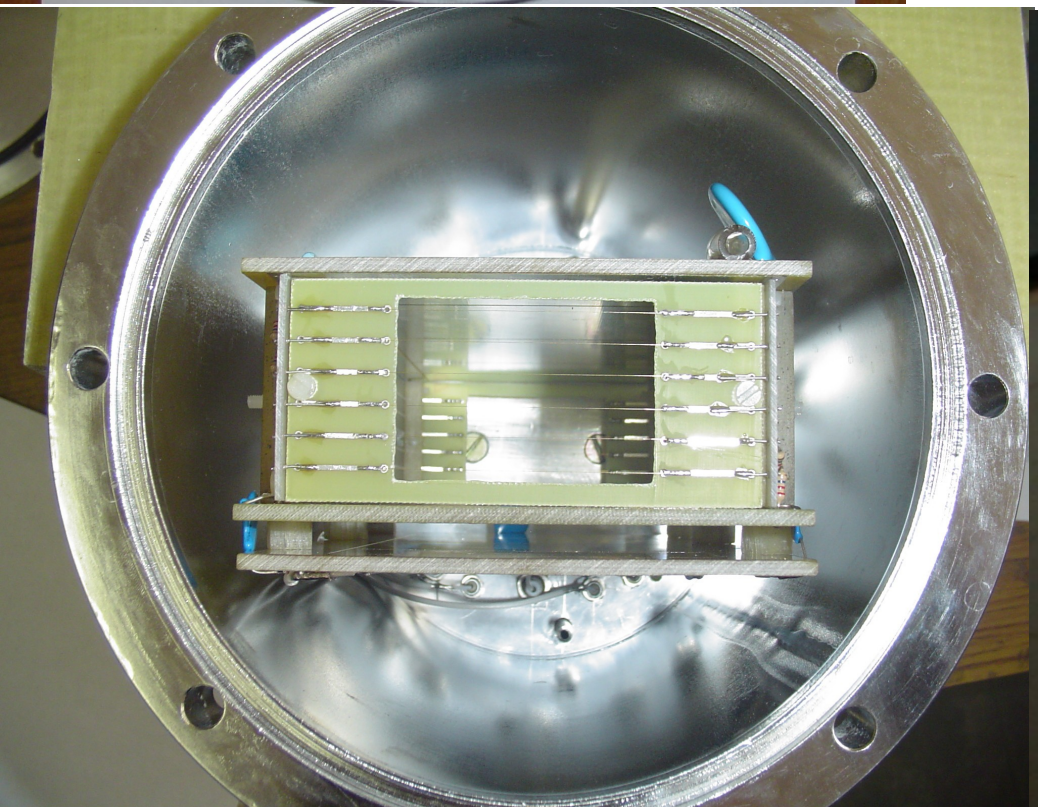
MWPC 8 ”X 4 ”
Electrodes : Au plated W wires –20 μ
Electrode separation : 3.5 mm
Rise time ~ 10 ns
TOF ~ 1 ns (fwhm), Positions ~ 1 mm (fwhm)

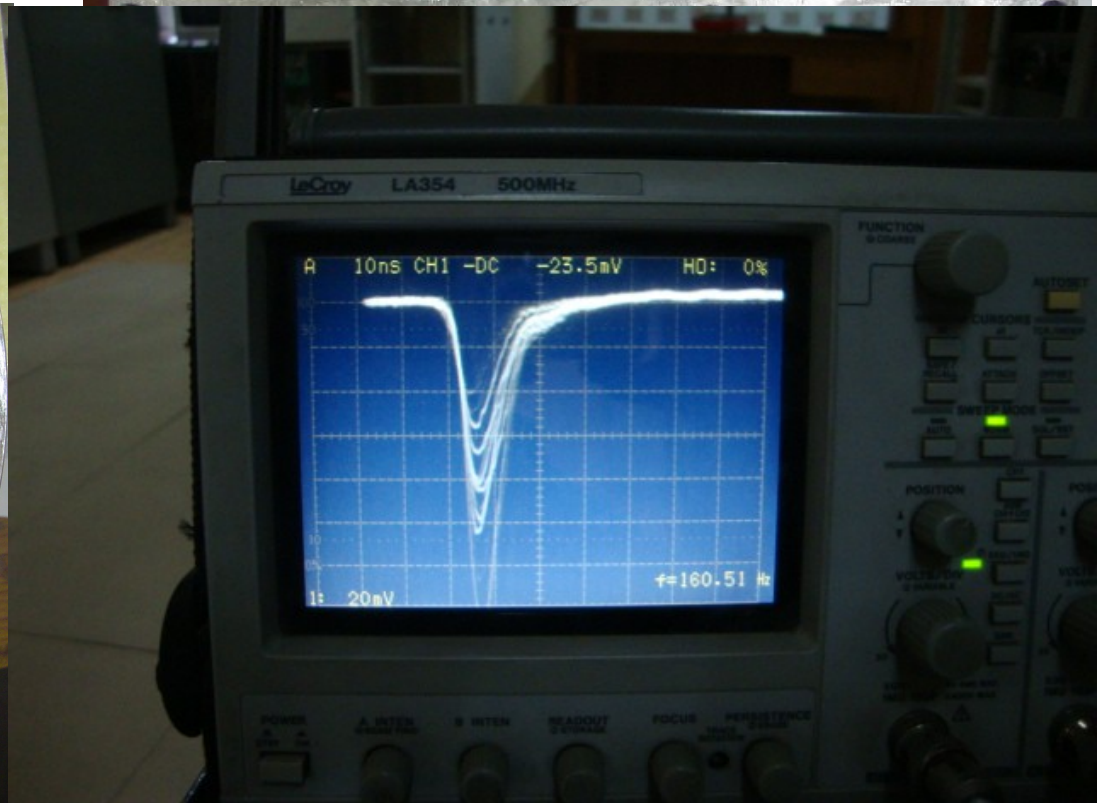
Small transmission MWPC 1.5 ” X 1.5 ”
Electrodes : Au plated W wires –20 μ
Electrode separation : 2 mm
Entrance and exit foils : 0.5μ mylar.
Rise times ~ 3.5 ns, TOF < 0.5 ns

Ref : A. Jhingan et. al. Rev. Sci. Instr. **80**, 123502 (2009)








LeCroy LA354 500MHz
A 10ns CH1 -DC -23.5mV HD: 0%
1: 20mV
f=160.51 Hz

2mx2m RPCs in Cosmic test

http://www.ino.tifr.res.in/ino/talks.php

Performance of HPTDC (Stop Watch)

32 Channels

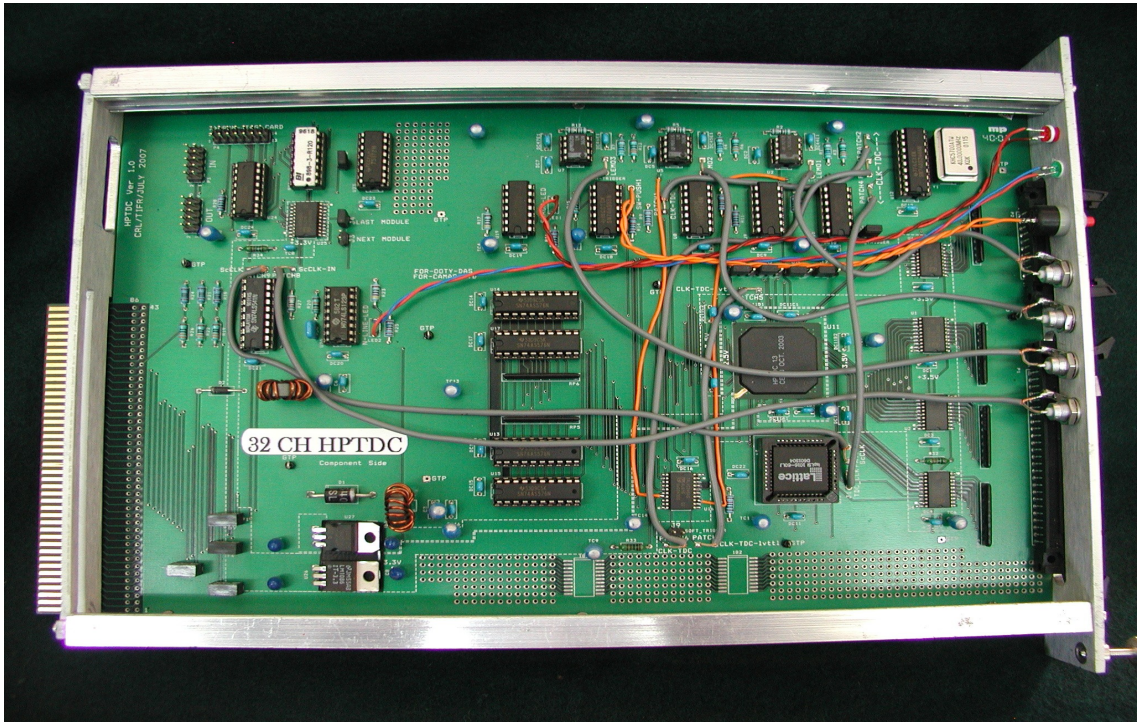
100 ps time resolution

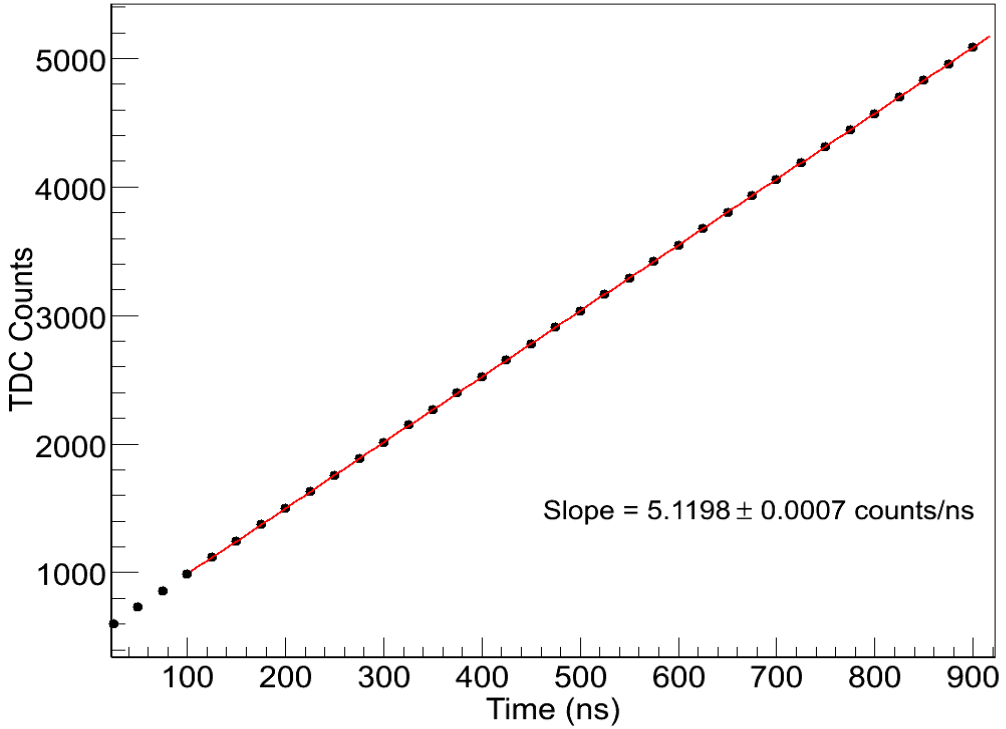
Multi-hit capability

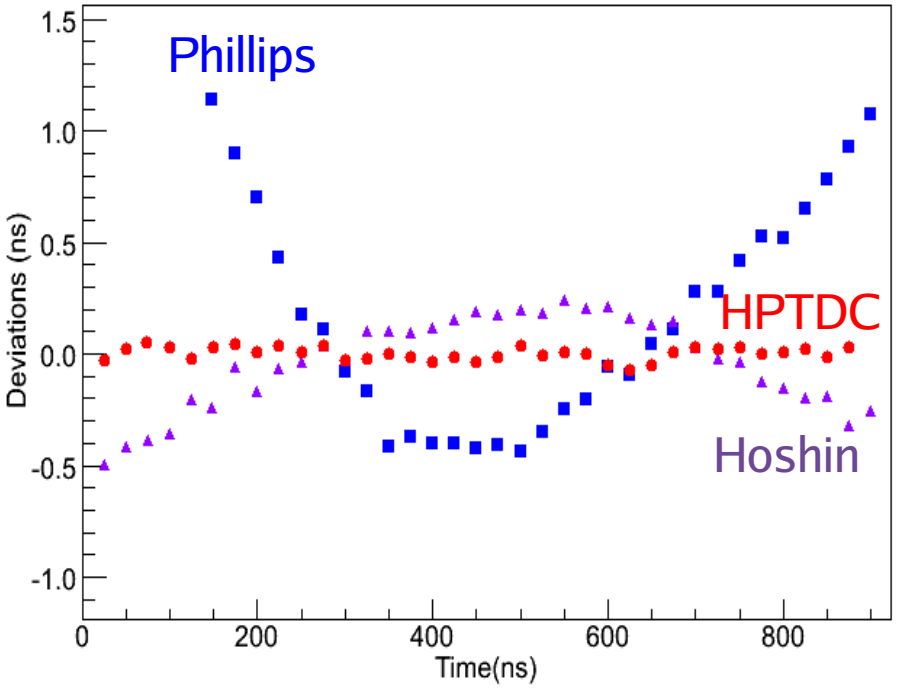
Huge dynamic range (100 ps - 50 μs)

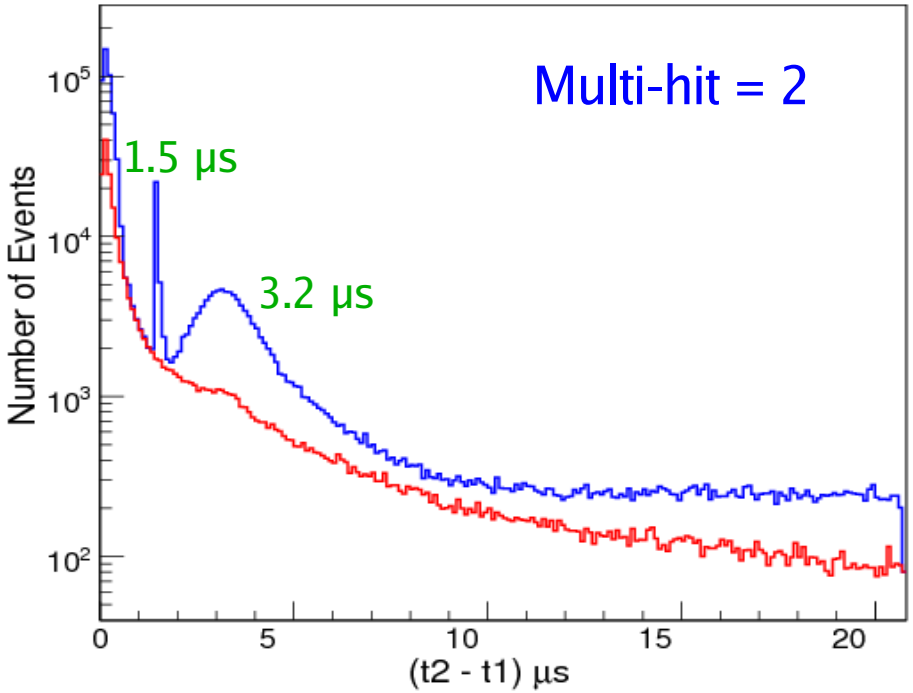
Trigger mode (avoids delay cables)

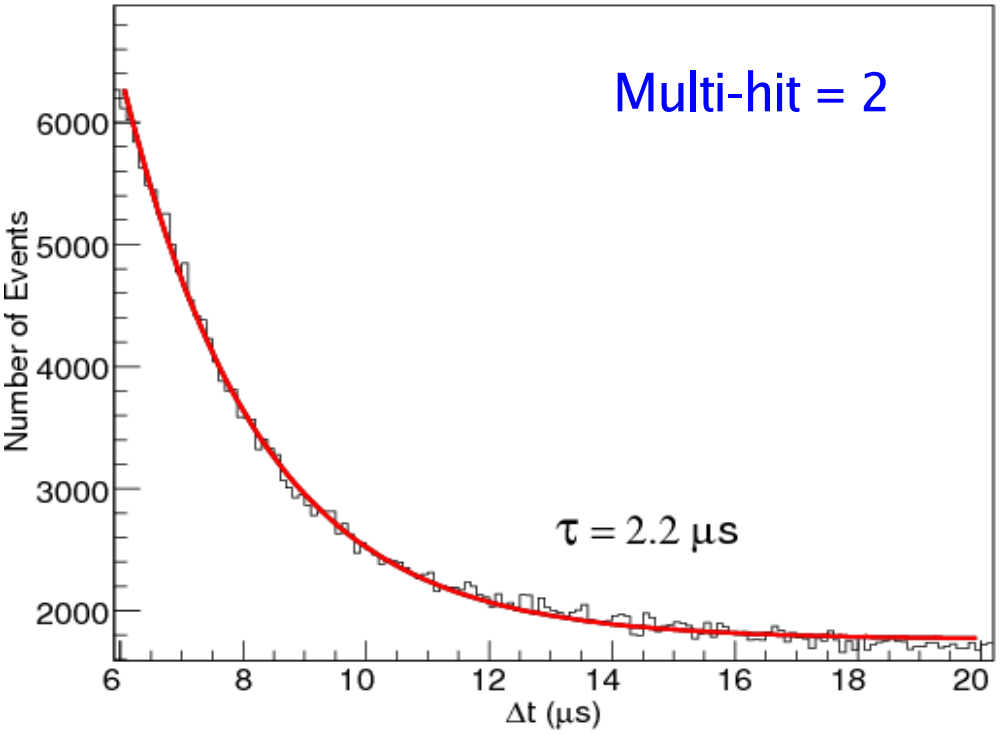
Requests: Atomic, Chemistry, Biology in TIFR, Oulu Finland, IUAC Delhi, Bose Institute, BARC etc.




TDC Counts
Time (ns)
Slope = 5.1198 ± 0.0007 counts/ns


Phillips
HPTDC
Hoshin
Deviations (ns)
Time(ns)


Multi-hit = 2
1.5 μs
3.2 μs
Number of Events
(t2 - t1) μs


Multi-hit = 2
τ = 2.2 μs
Number of Events
Δt (μs)

Current Scene

Gaseous Detectors:

Multi Wire Proportional Counters

Scintillator Detectors:

Plastic Scintillators

Semiconductor Detectors:

Double-sided Silicon Detectors,Silicon Photomultipliers

Electronics:

Digital Signal Processing

Challenges in Detection & Measurement of Charged Particles & Photons

Timing	~10 ps
Position	~50 μ
Direction	~1 μ ad
Sensor Area	~10 X
Quantum Eff	~100%
Rad Harder	

THANKS