Lab Orientation – Part II

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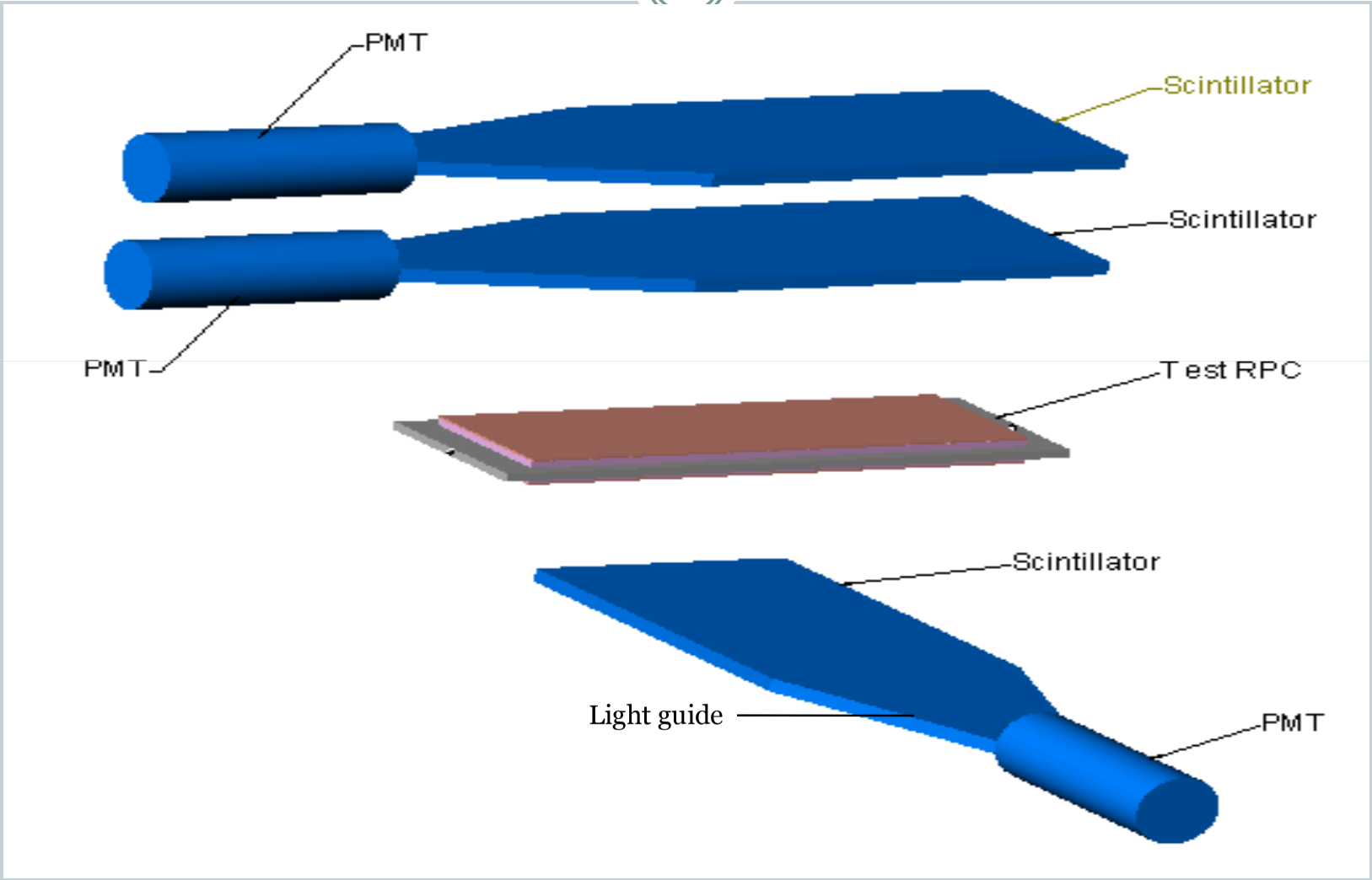
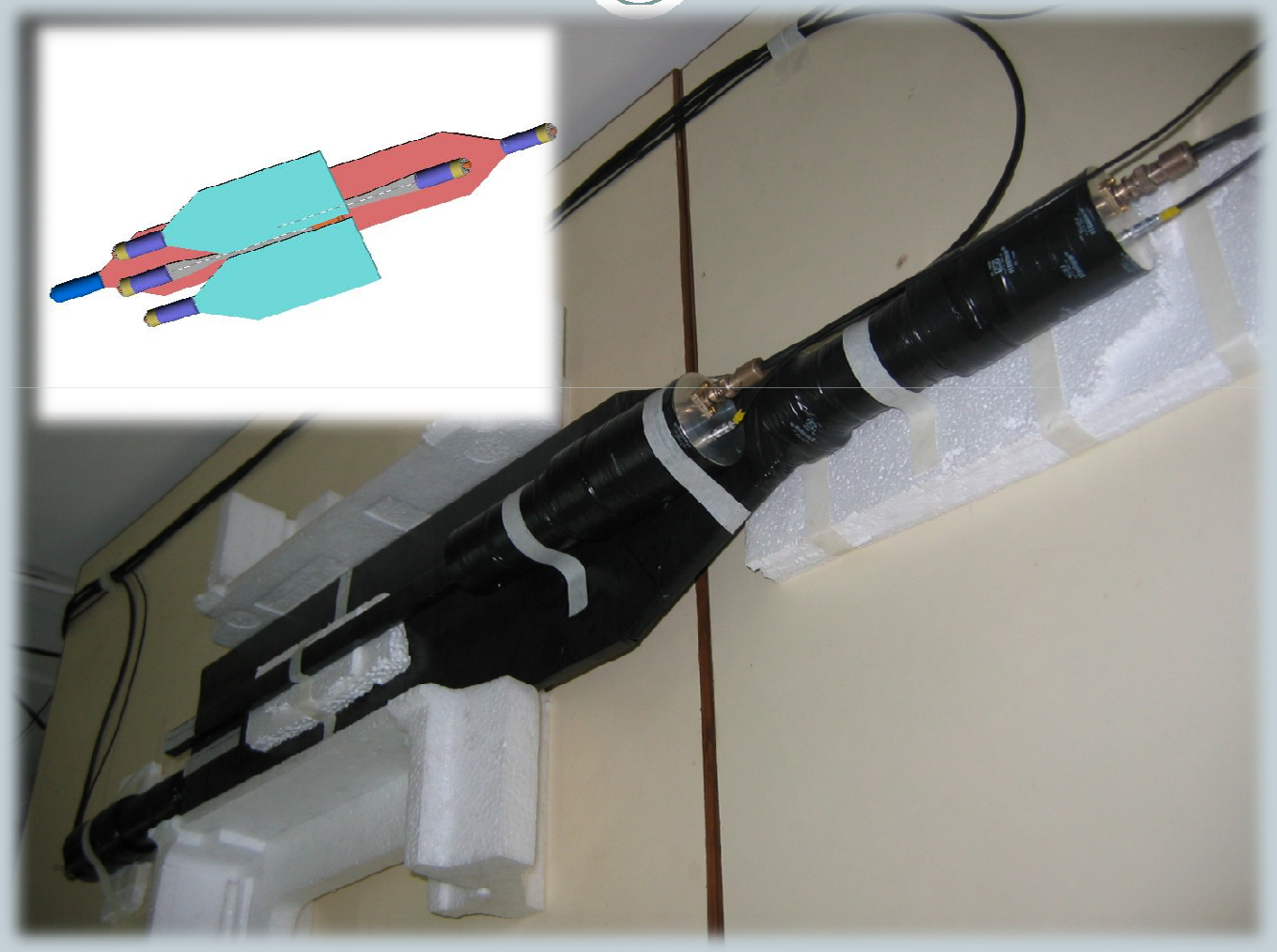
Hardware experiments

1. Scintillator paddle based cosmic ray telescope
2. Fabrication and characterising RPCs
3. Muon lifetime measurement
4. Compton scattering
5. Annihilation radiation coincidence study
6. Study of Silicon Micro Strip detectors

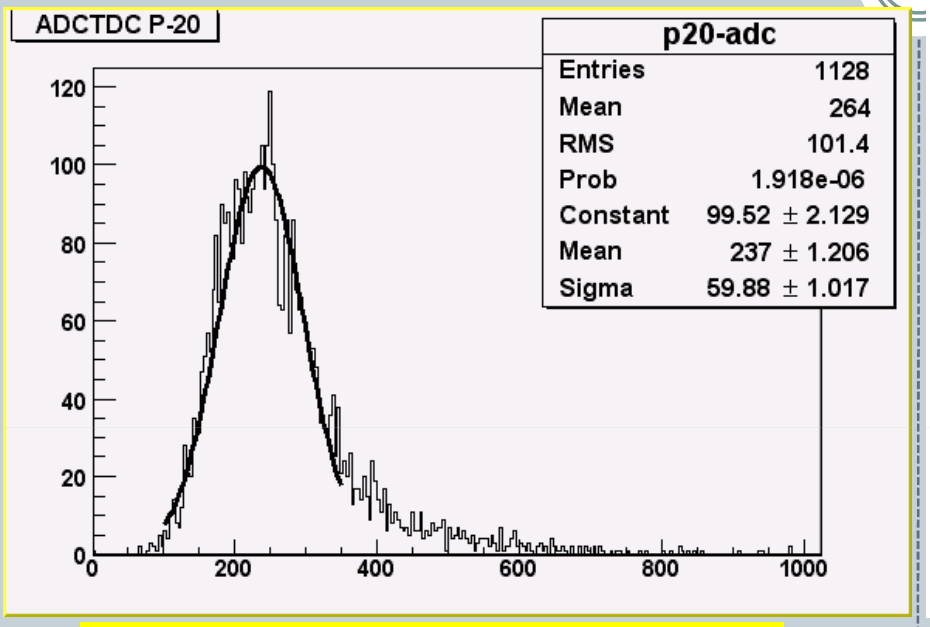
Scintillator paddle based cosmic ray telescope-1



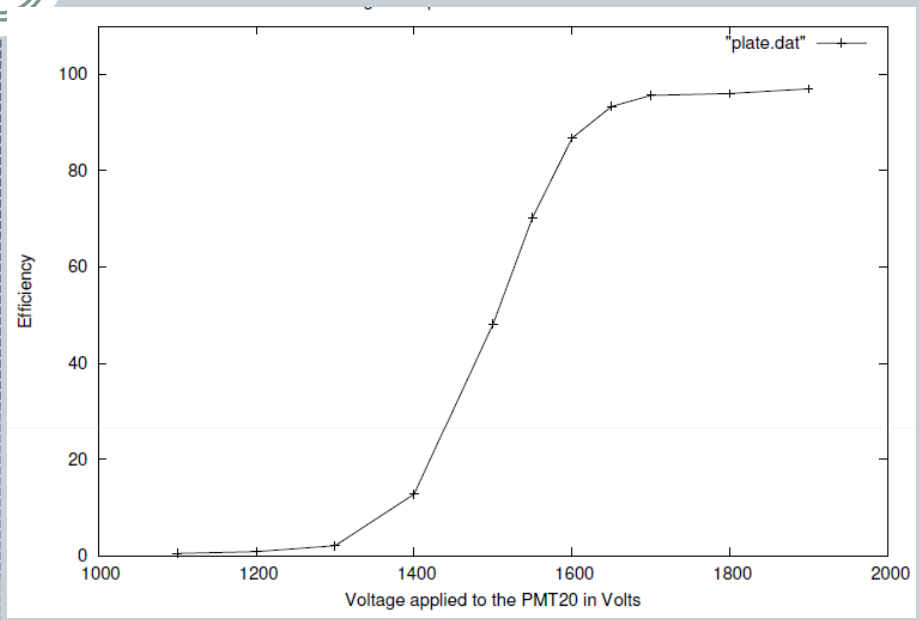
Scintillator paddle based cosmic ray telescope-2



Scintillator paddle based cosmic ray telescope-3



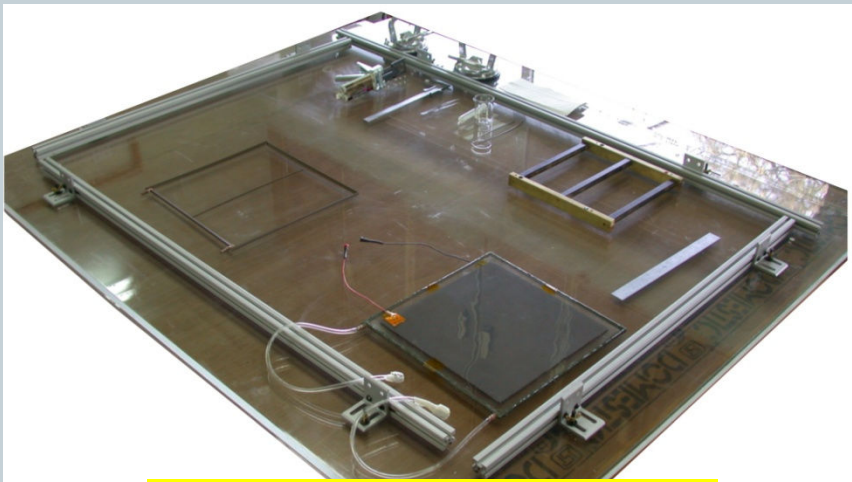
Charge distribution of a scintillator paddle



Efficiency plateau of a scintillator paddle

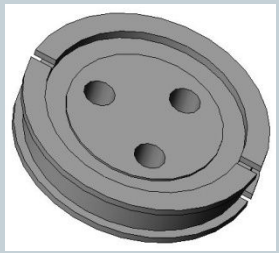
- Counting rate as a function of threshold
- Chance coincidence calculation and verification

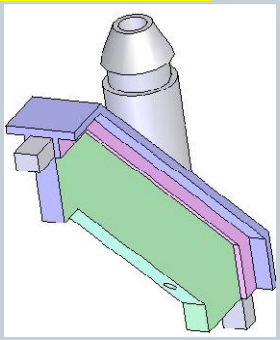
Fabrication and characterising RPCs-1

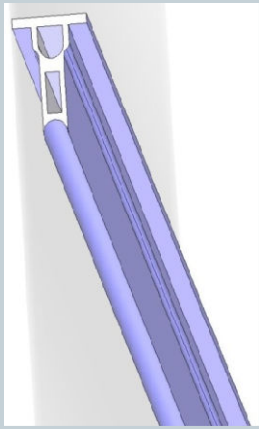


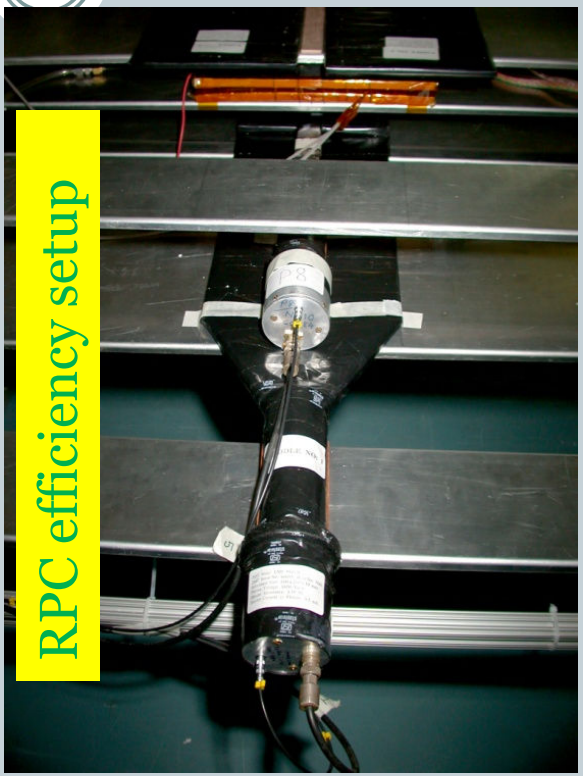
RPC fabrication & jigs

RPC components









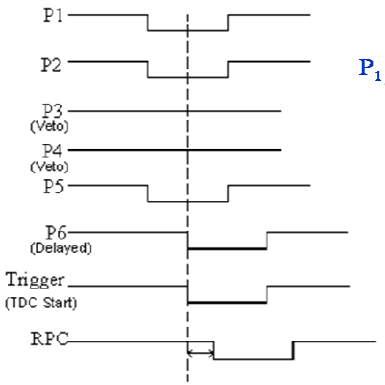
RPC efficiency setup

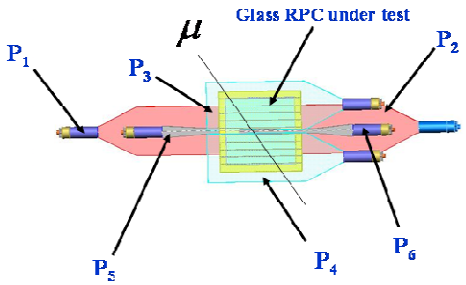
Gas system

Pickup panel

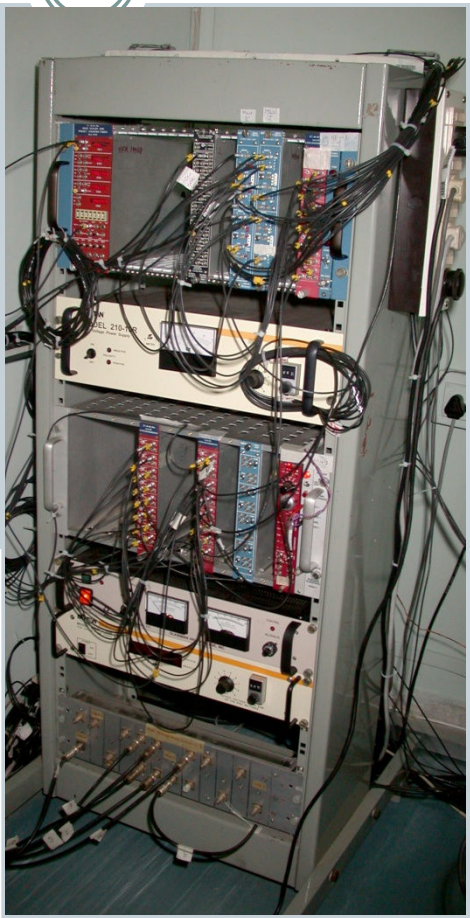
Fabrication and characterising RPCs-2

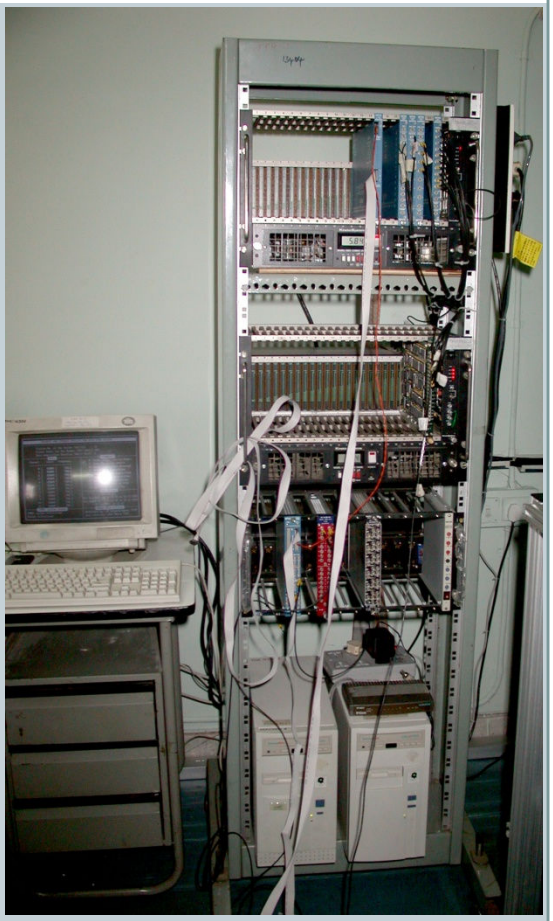
Cosmic Ray Telescope





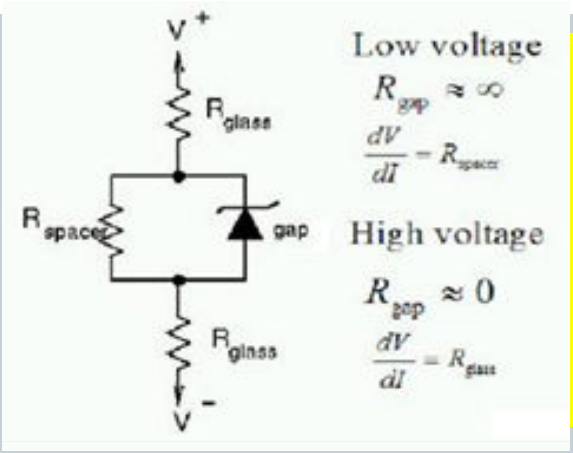
Muon Trigger = $P_1 \bullet P_2 \bullet \overline{P}_3 \bullet \overline{P}_4 \bullet P_5 \bullet P_6$



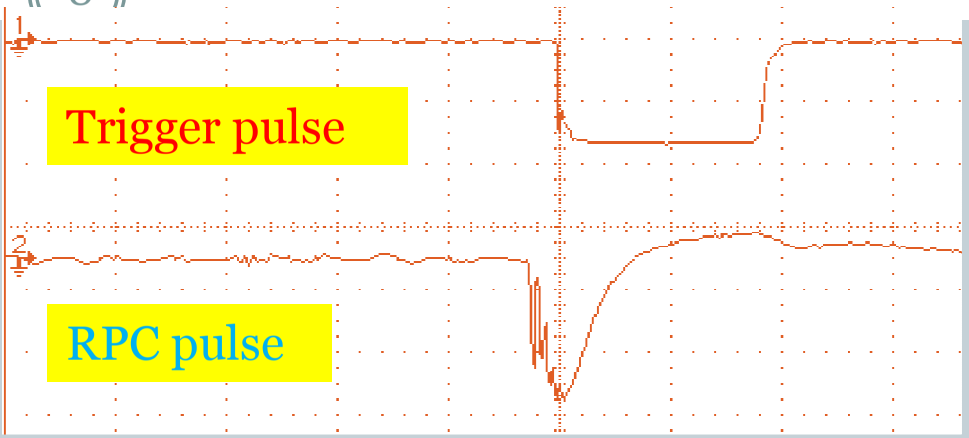


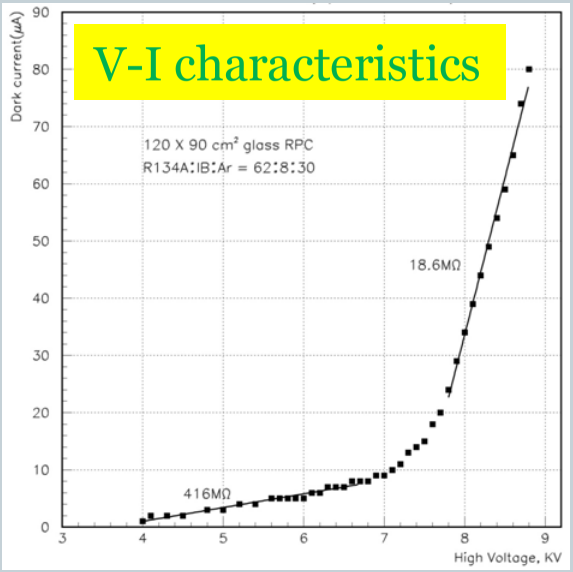
Electronics & DAQ system

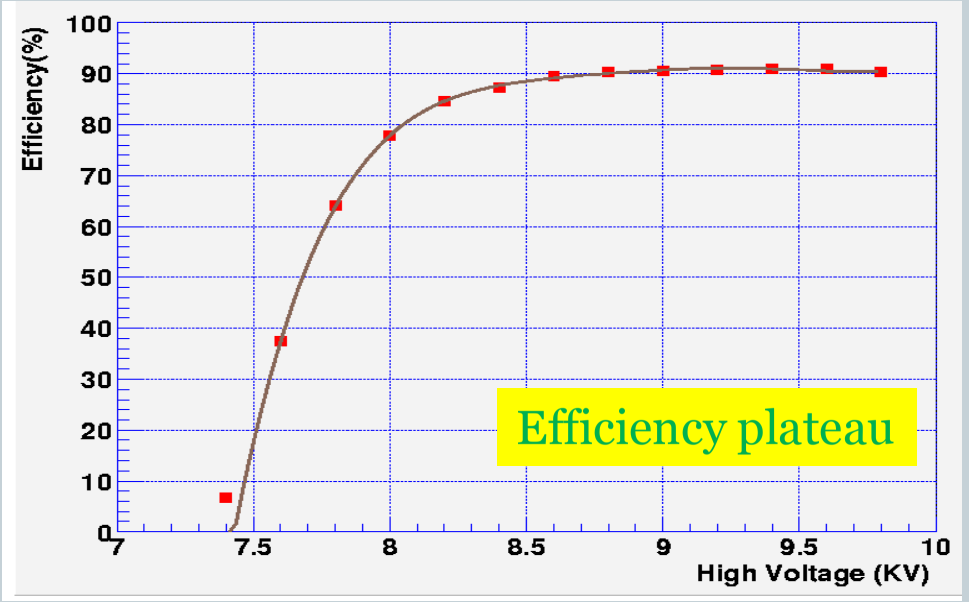
Fabrication and characterising RPCs-3



Electrical model

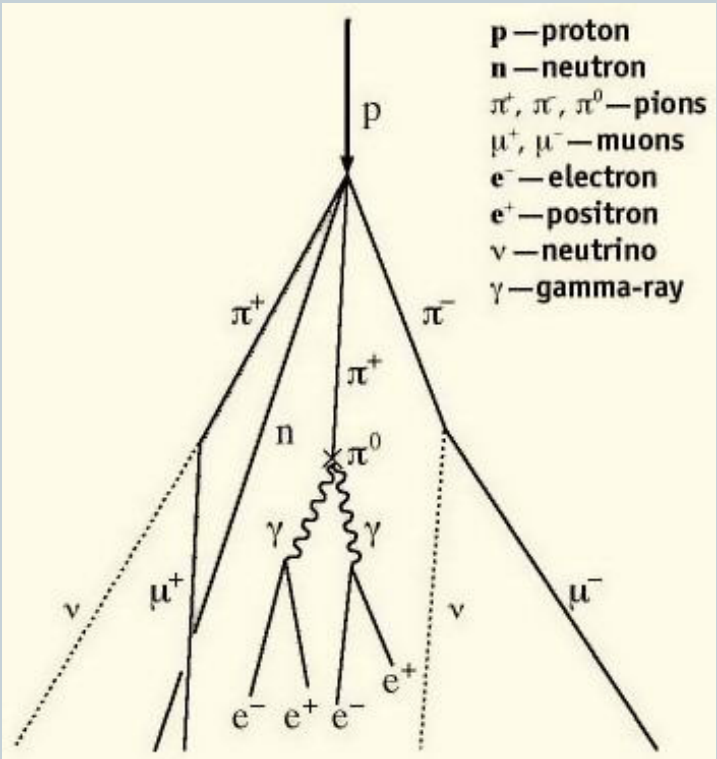




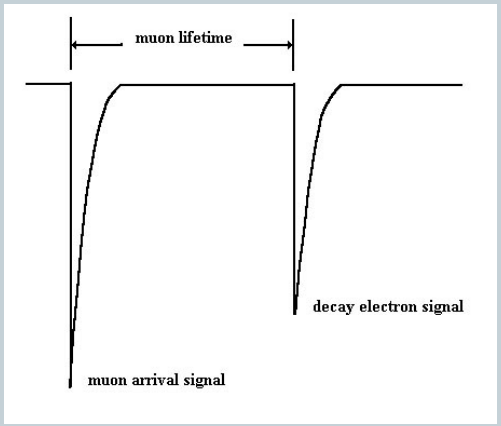


Muon lifetime measurement-1

An indirect verification of special theory of relativity using cosmic ray muons



$$p + p \rightarrow p + p + \pi^+ + \pi^-$$
$$\pi^+ \rightarrow \mu^+ + \nu_\mu$$
$$\pi^- \rightarrow \mu^- + \bar{\nu}_\mu$$
$$\mu^+ \rightarrow e^+ + \bar{\nu}_\mu + \nu_e$$
$$\mu^- \rightarrow e^- + \nu_\mu + \bar{\nu}_e$$



Muon lifetime measurement-2

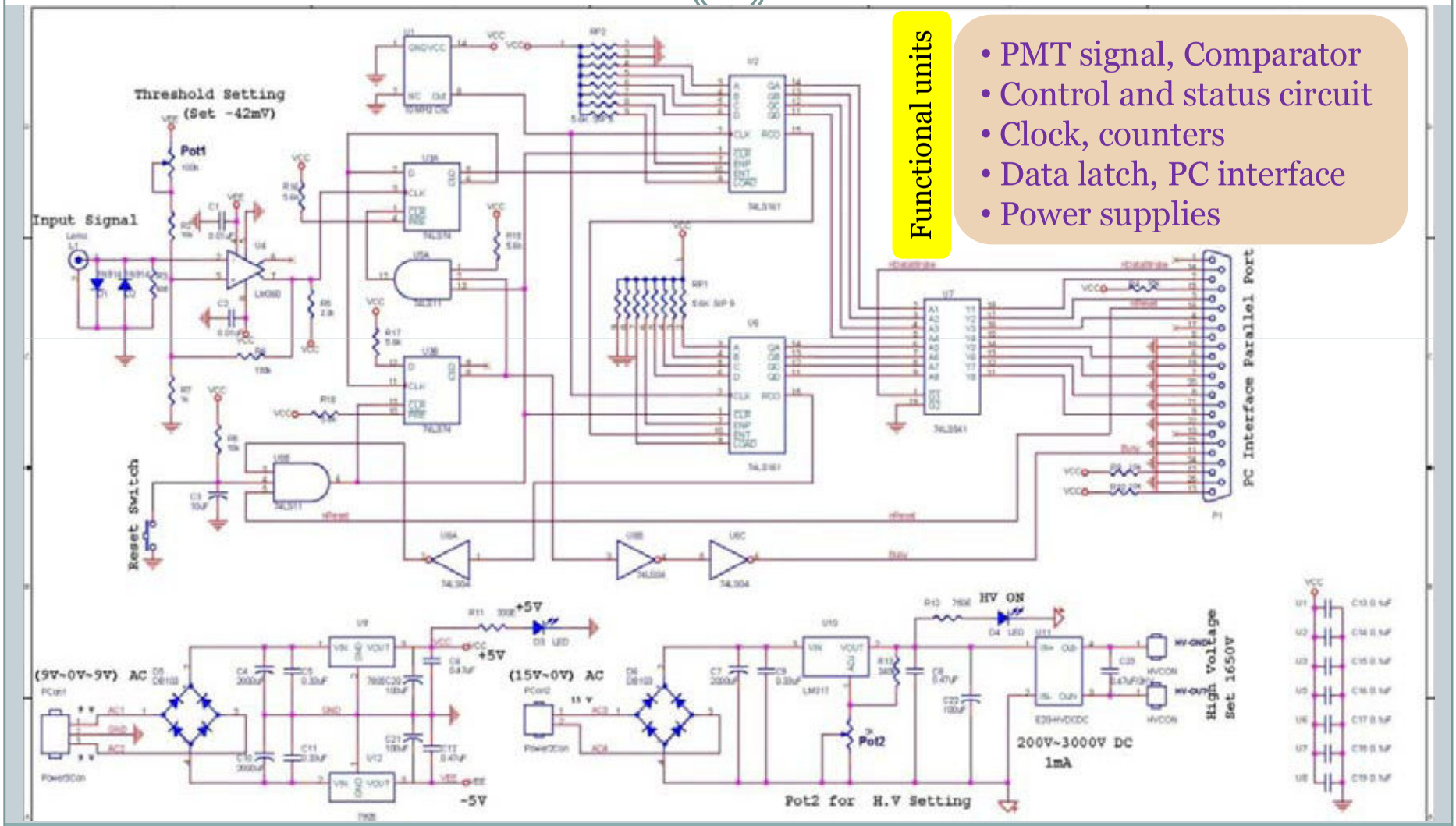
25cm ×25cm × 15cm
plastic scintillator block

Data acquisition and
power supply module

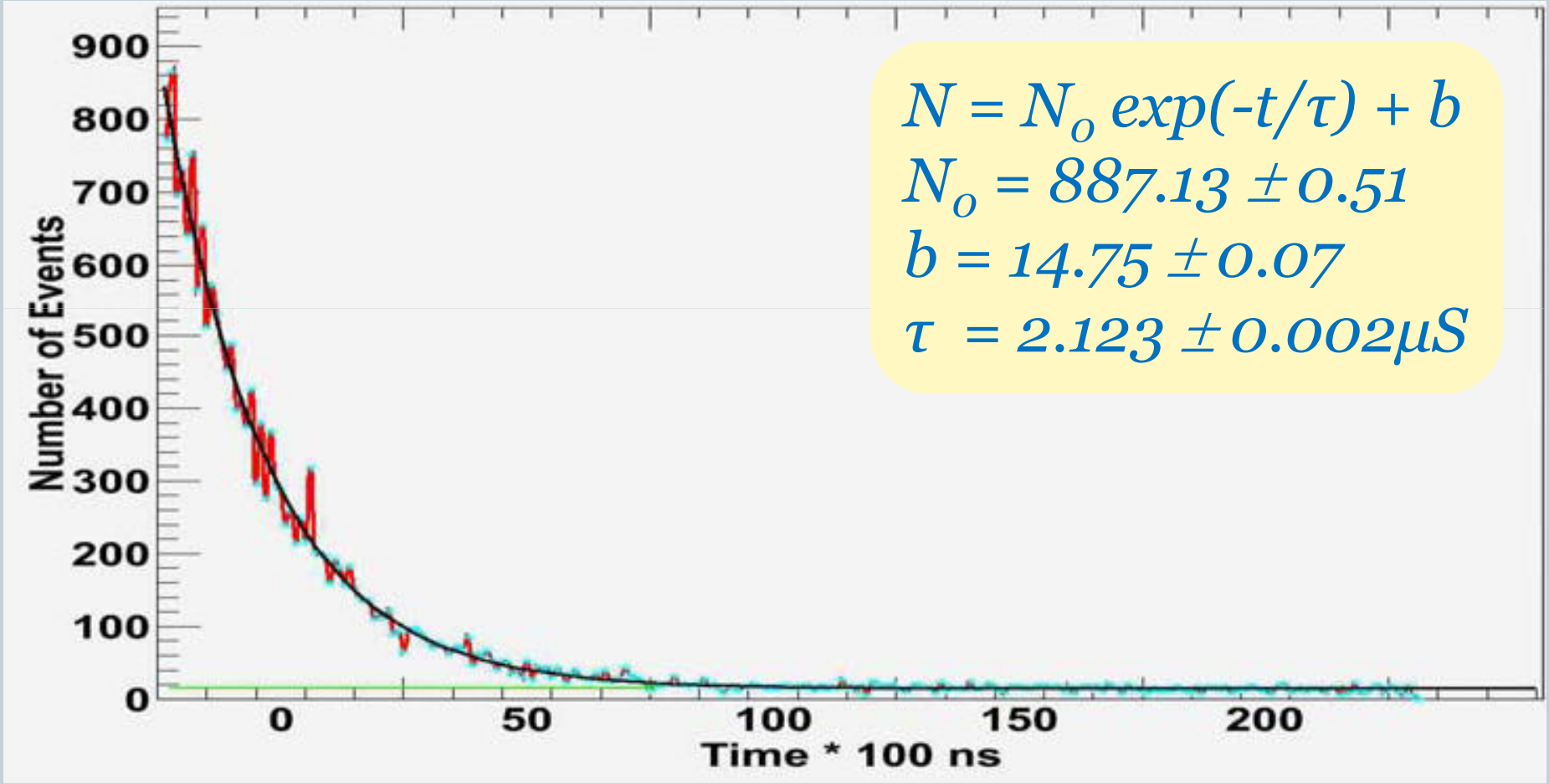
Muon lifetime measurement-3

Functional units

- PMT signal, Comparator
- Control and status circuit
- Clock, counters
- Data latch, PC interface
- Power supplies



Muon lifetime measurement-4



$N = N_0 \exp(-t/\tau) + b$

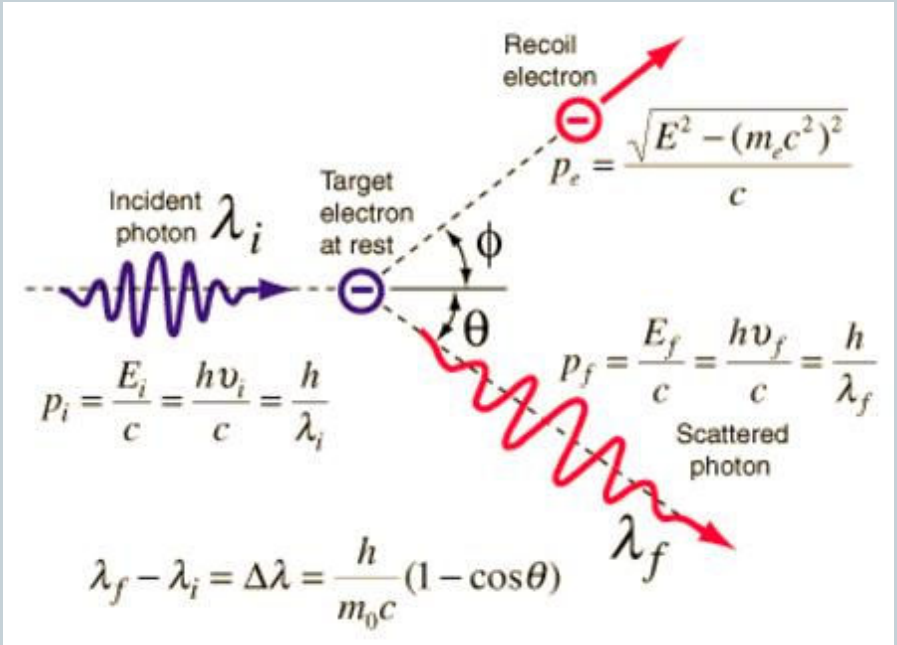
$N_0 = 887.13 \pm 0.51$

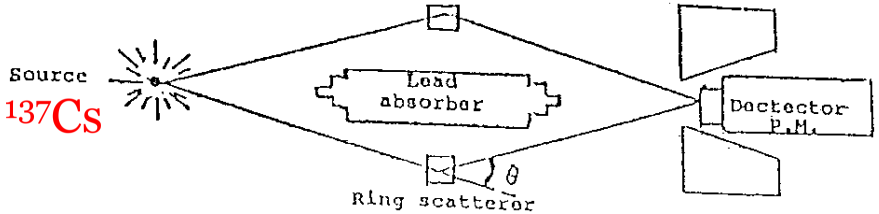
$b = 14.75 \pm 0.07$

$\tau = 2.123 \pm 0.002 \mu S$

Crompton scattering-1

Determine the energy of Compton scattered photon at the angle θ and compare the result with the theoretically calculated value. Also find the differential Compton scattering cross-section for Al or Cu scatterer.

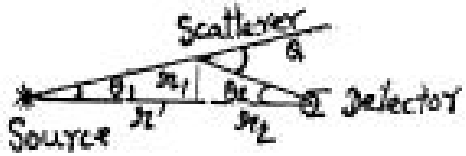


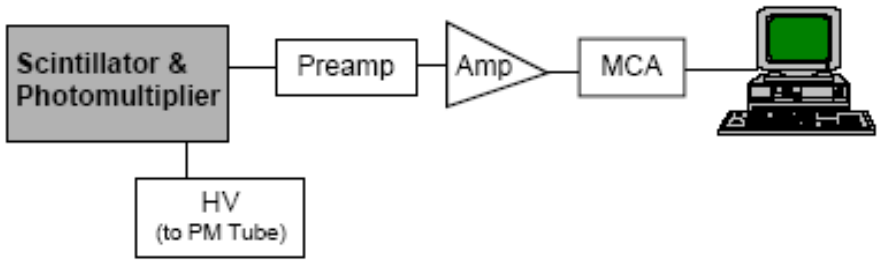


'2π – geometry' (ring scatterer)

Determine the scattering angle θ by finding the ring's radius (r_1). distance between source and the ring(r'), distance between ring and the detector (r_2).

$$\theta = \theta_1 + \theta_2 \equiv \tan^{-1}\frac{r_1}{r'} + \tan^{-1}\frac{r_1}{r_2}$$





Data acquisition system

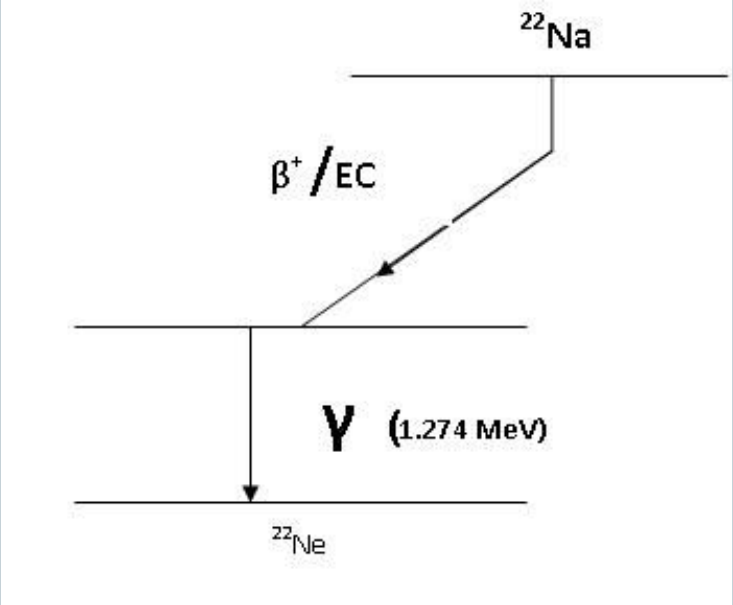
Crompton scattering-2

- Scattering angle θ found from the 'geometry' of the set up
- Energy of the scattered photon is calculated from the Compton formula.
- Calibration of the detector with standard γ ray energy sources enables one to determine experimentally the energy of the photon scattered at angle θ.
- Differential scattering cross section $d\sigma/d\Omega$ at angle θ measured from the known target parameters:
  - Crystal size & its efficiency
  - Source strength
  - Number of scattered photons detected per unit time

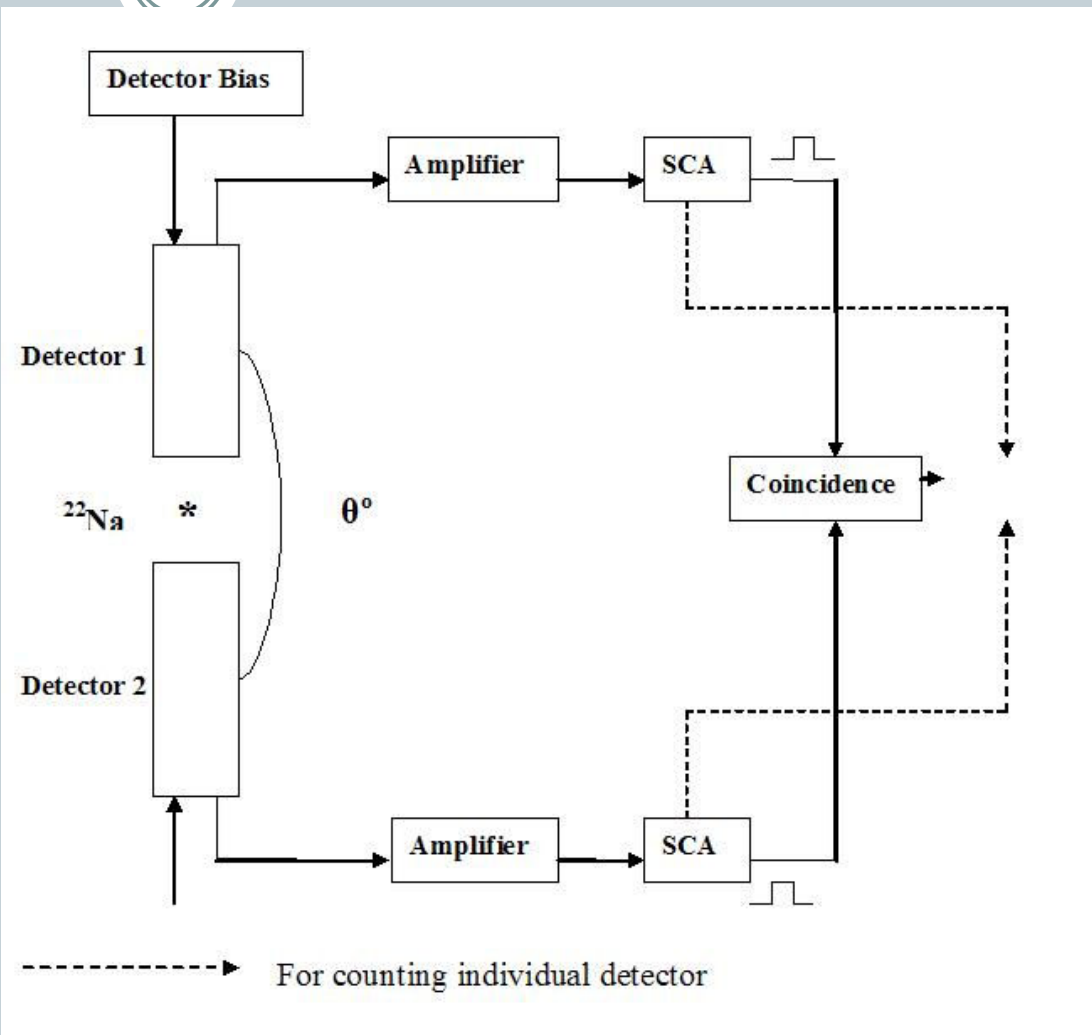
Annihilation radiation coincidence study-1

- The radioactive source ^{22}Na decays to ^{22}Ne via β^+ (emission of positron) or EC (electron capture).
- The β^+ particles quickly combine with electrons of the surrounding material, emitting two gamma photons each of energy 0.511 MeV.
- These two photons are called annihilation radiation and they move in opposite direction to conserve the linear momentum.
- In the coincidence experiment using two NaI (Tl) detectors, we verify that the angular separation between two annihilation radiation is 180°.
- Experimentally the pair of gamma rays is detected and measured with one detector that is fixed and another detector that can rotate about the source.

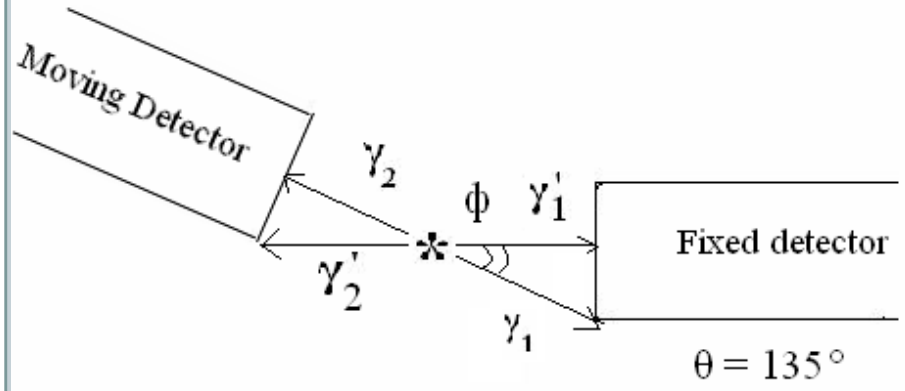
Annihilation radiation coincidence study-2

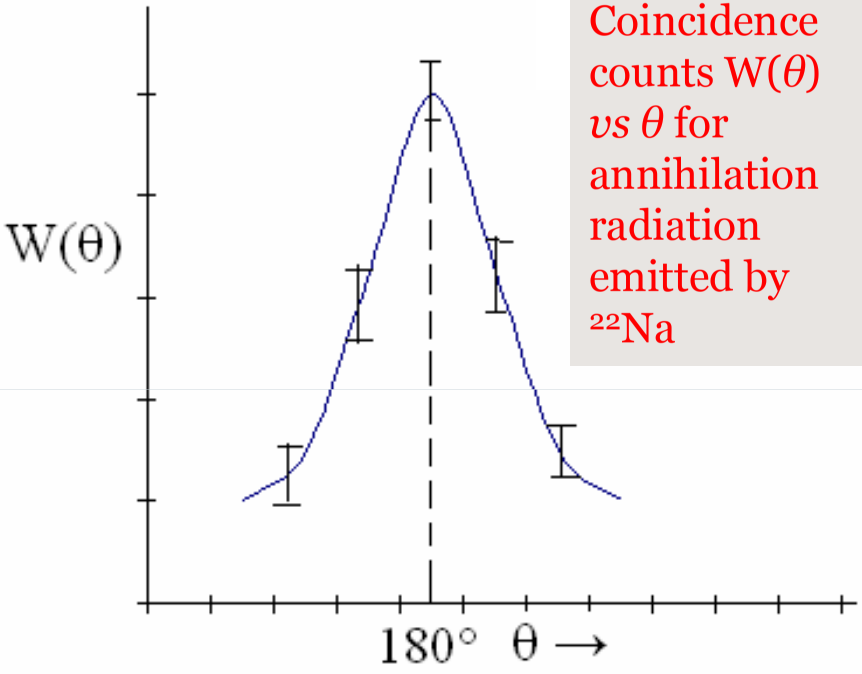


Decay scheme of ^{22}Na

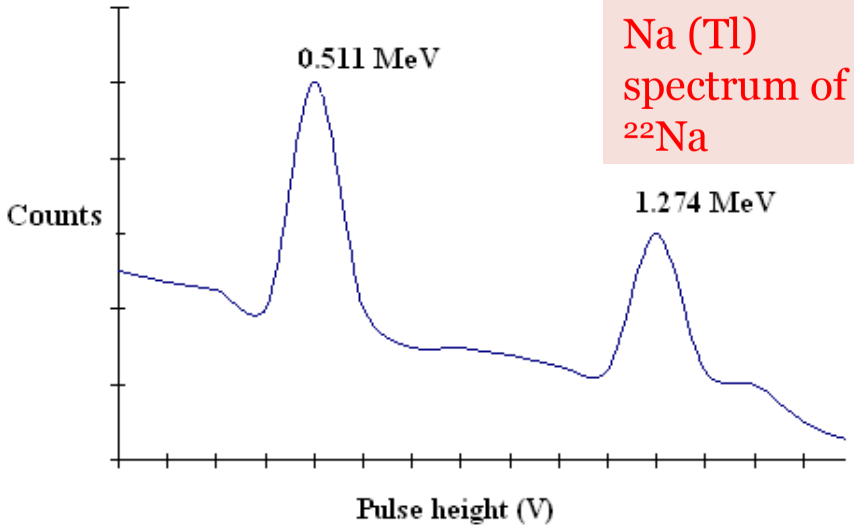


Annihilation radiation coincidence study-3

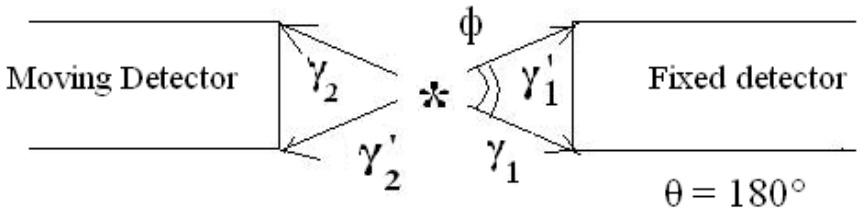




Coincidence counts W(θ) *vs* θ for annihilation radiation emitted by ^{22}Na

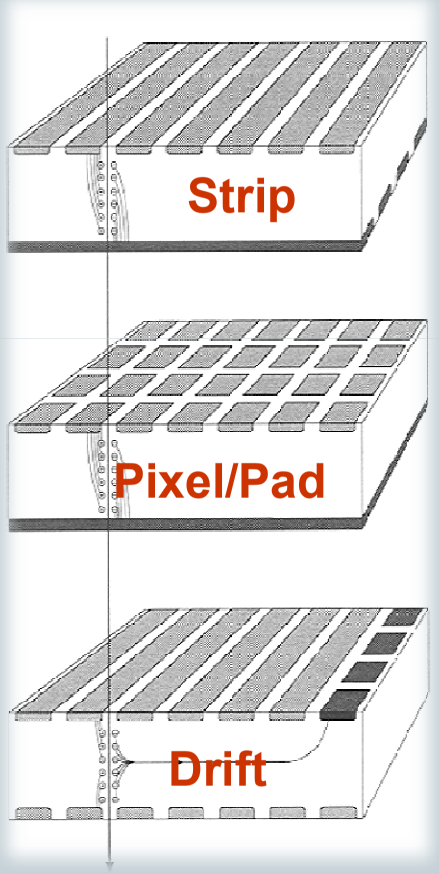


Na (Tl) spectrum of ^{22}Na

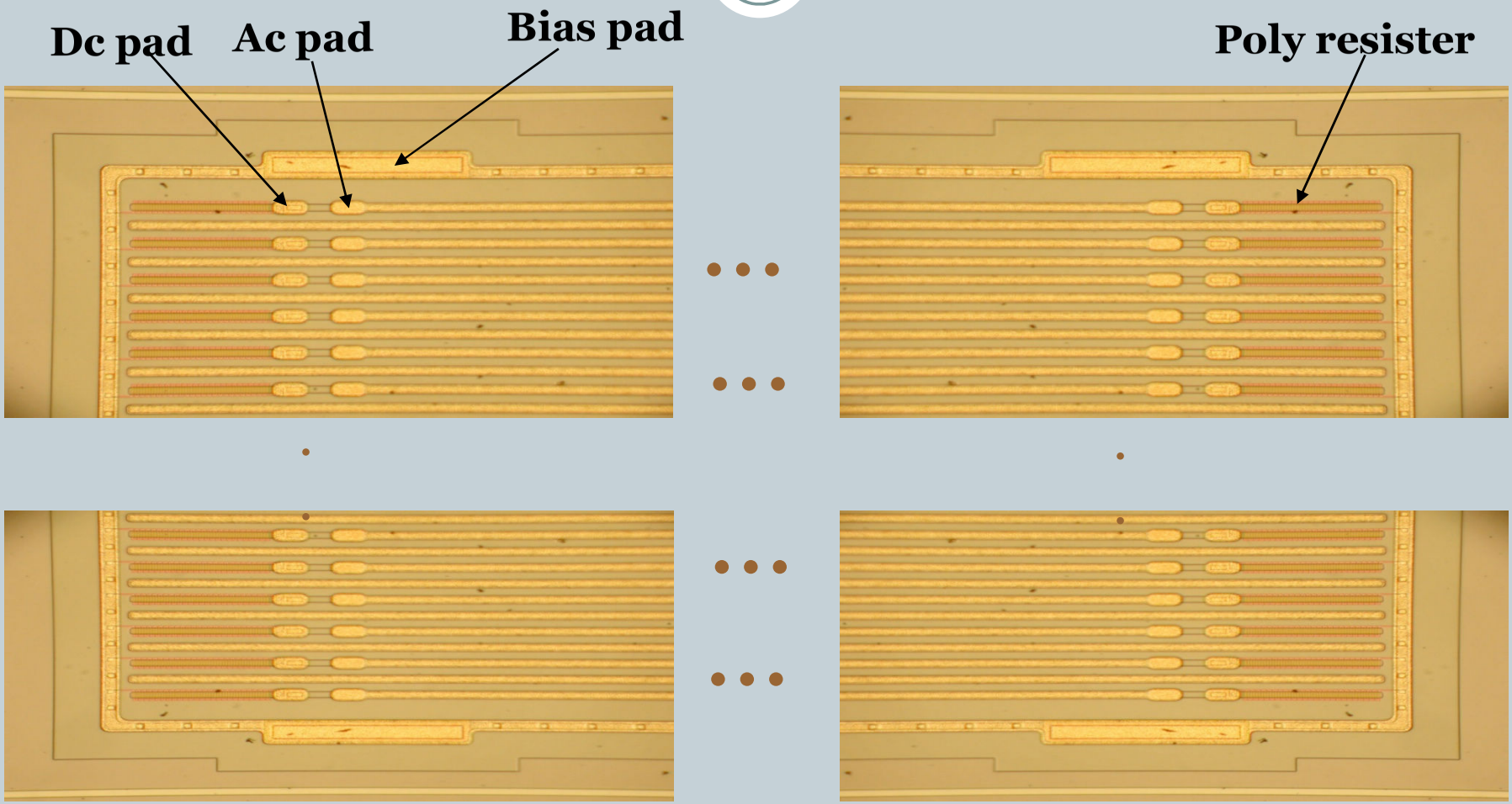


Study of Silicon Micro Strip detectors-1

- Strip devices
  - High precision (< 5μm) 1-D coordinate measurement
  - Large active area (up to 10cm × 10cm from 6" wafers)
  - Single-sided devices
  - 2nd coordinate possible (double-sided devices)
  - Most widely used silicon detector in HEP
- Pixel devices
  - True 2-D measurement (20μm pixel size)
  - Small areas but best for high track density environment
- Pad devices ("big pixels or wide strips")
  - Pre-shower and calorimeters
- Drift devices



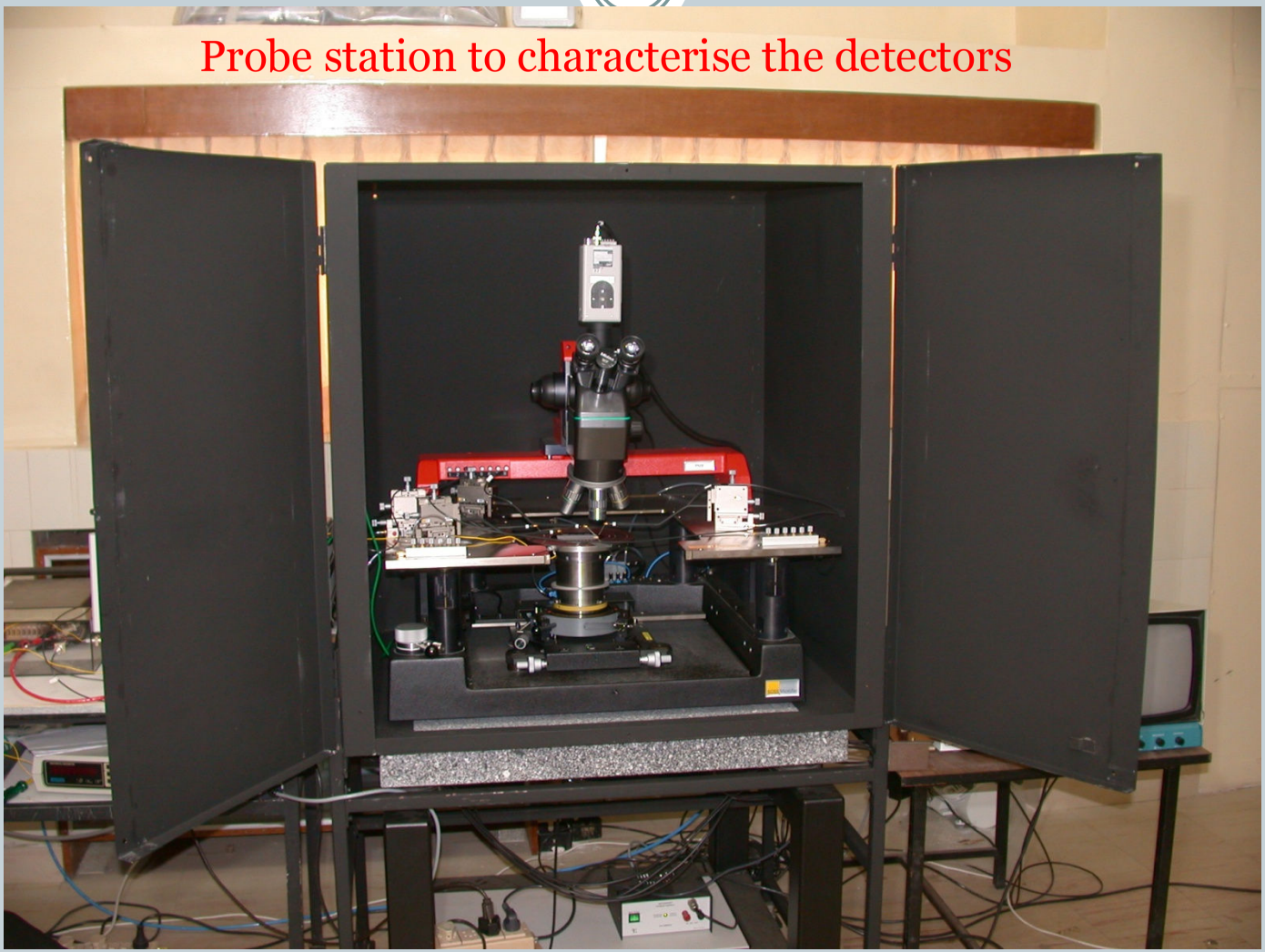
Study of Silicon Micro Strip detectors-2



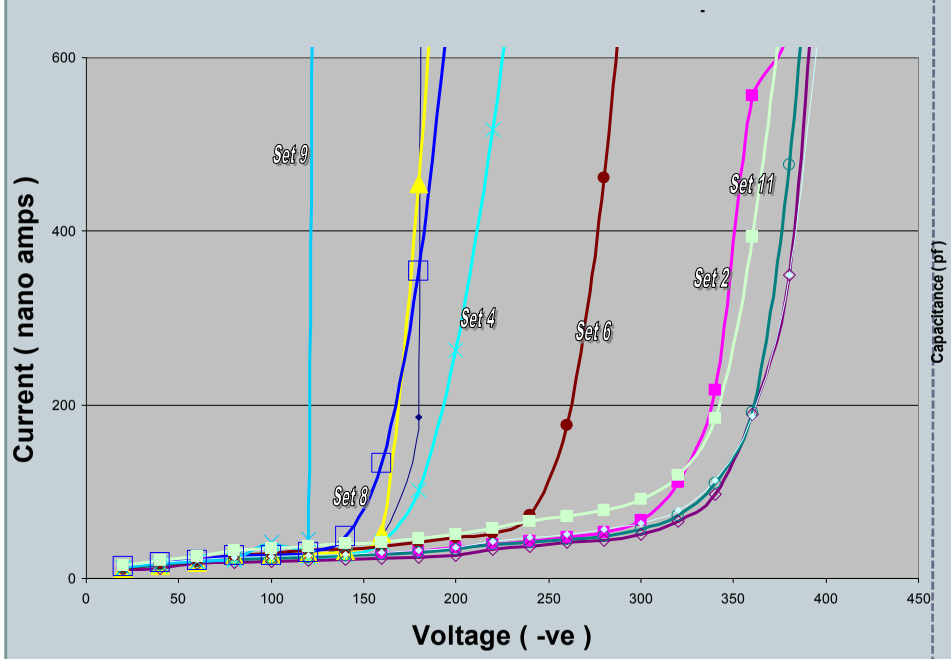
Single strip Silicon Micro Strip detector

Study of Silicon Micro Strip detectors-3

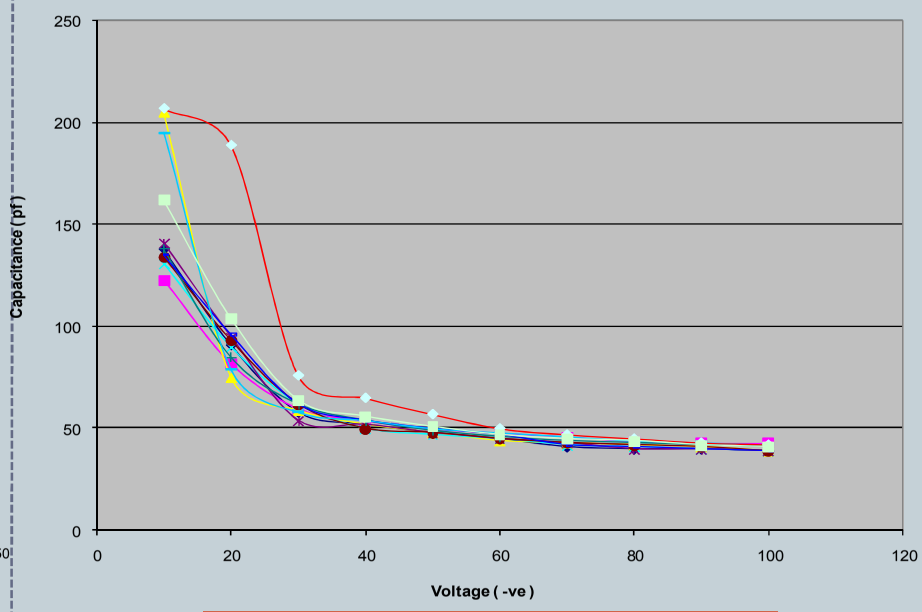
Probe station to characterise the detectors



Study of Silicon Micro Strip detectors-4

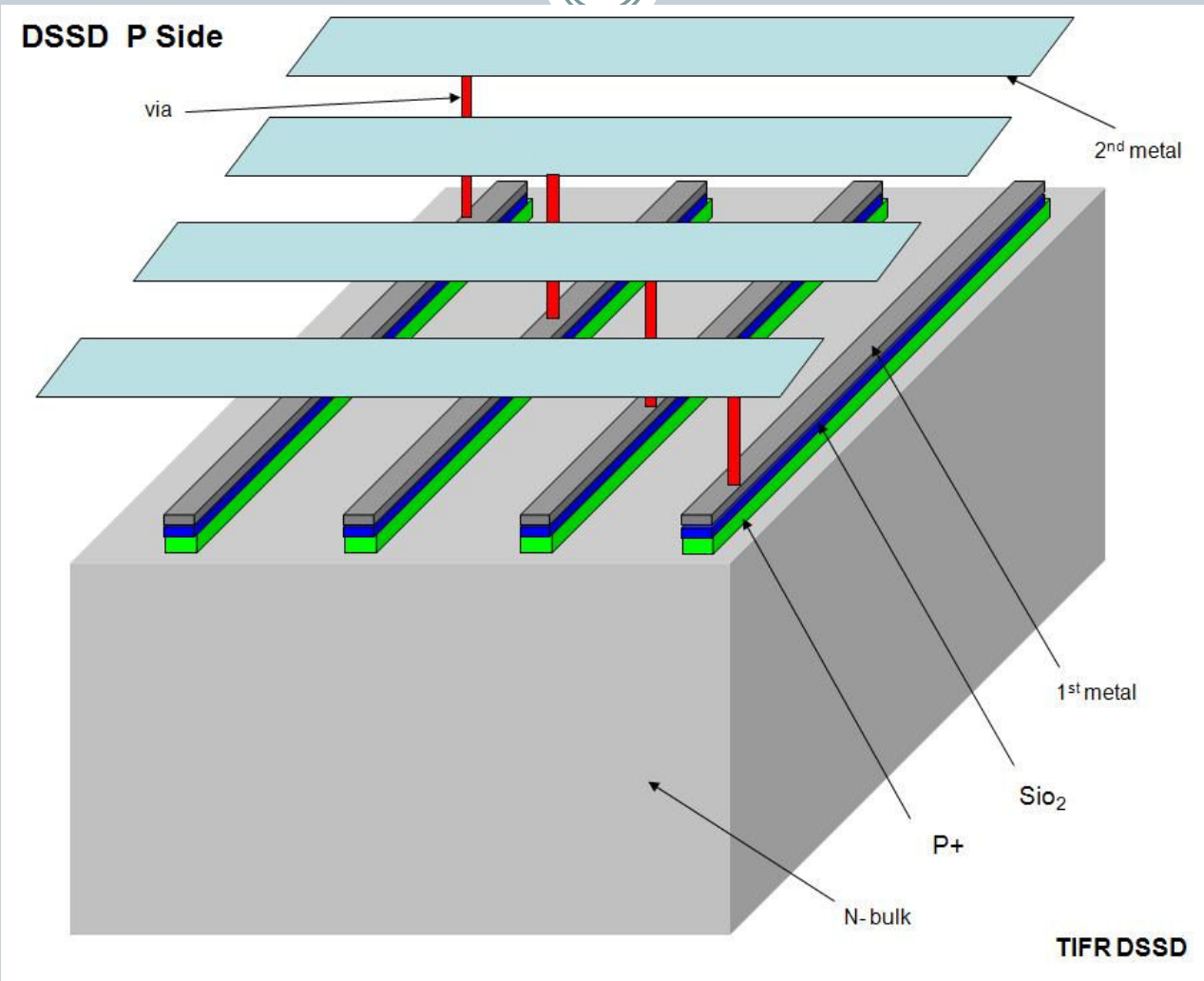


I-V characteristics



C-V characteristics

Study of Silicon Micro Strip detectors-5



All the best

HOPE THAT THIS SCHOOL WILL MAKE YOU A BETTER EXPERIMENTALIST