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On behalf of the INO Collaboration

GLASS RPC DETECTOR R&D FOR AN INDIAN MEGA NEUTRINO PHYSICS DETECTOR

Plan of the presentation

- Introduction to the neutrino detector
- Early work on 30cm × 30cm RPCs
- Materials and infrastructure development
- Development of 1m × 1m RPCs
- Prototype detector stack
- Development of 2m × 2m RPCs
- Status and summary

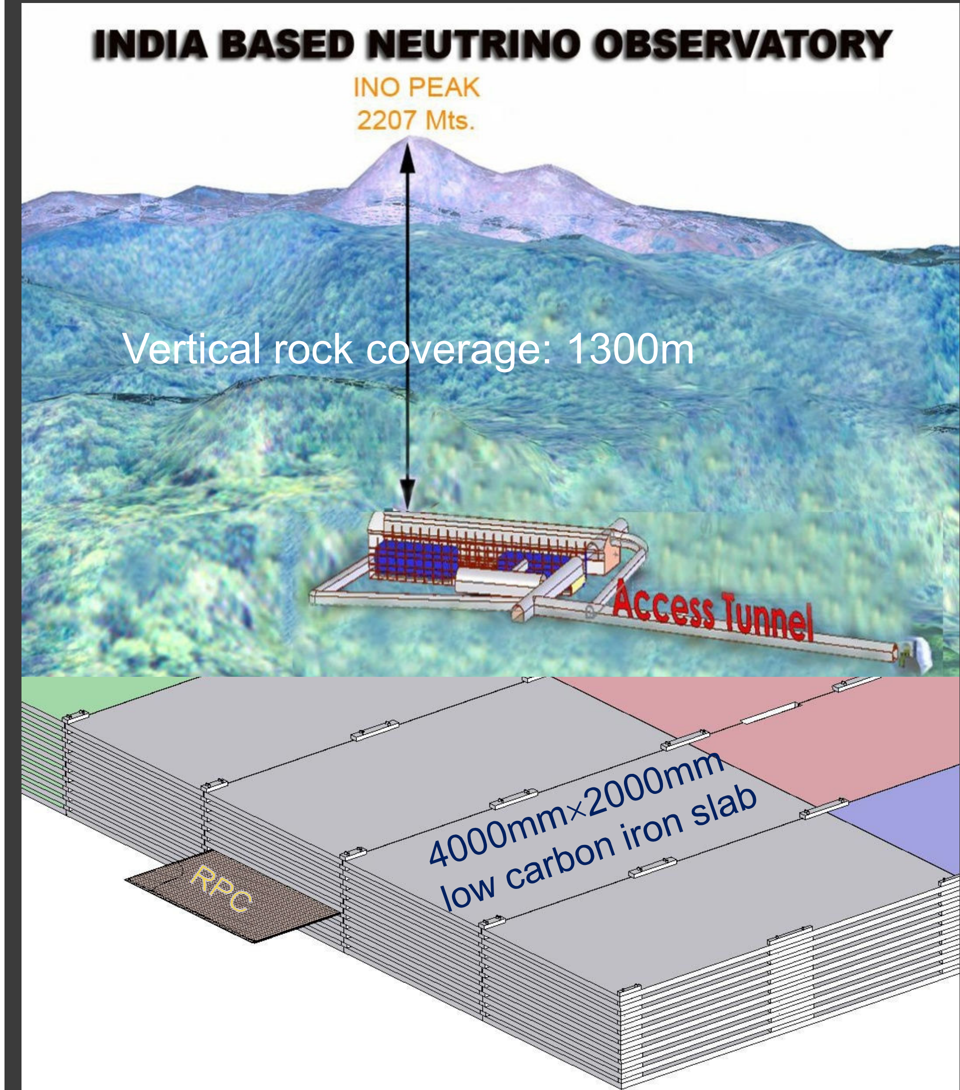
Physics programme of the detector

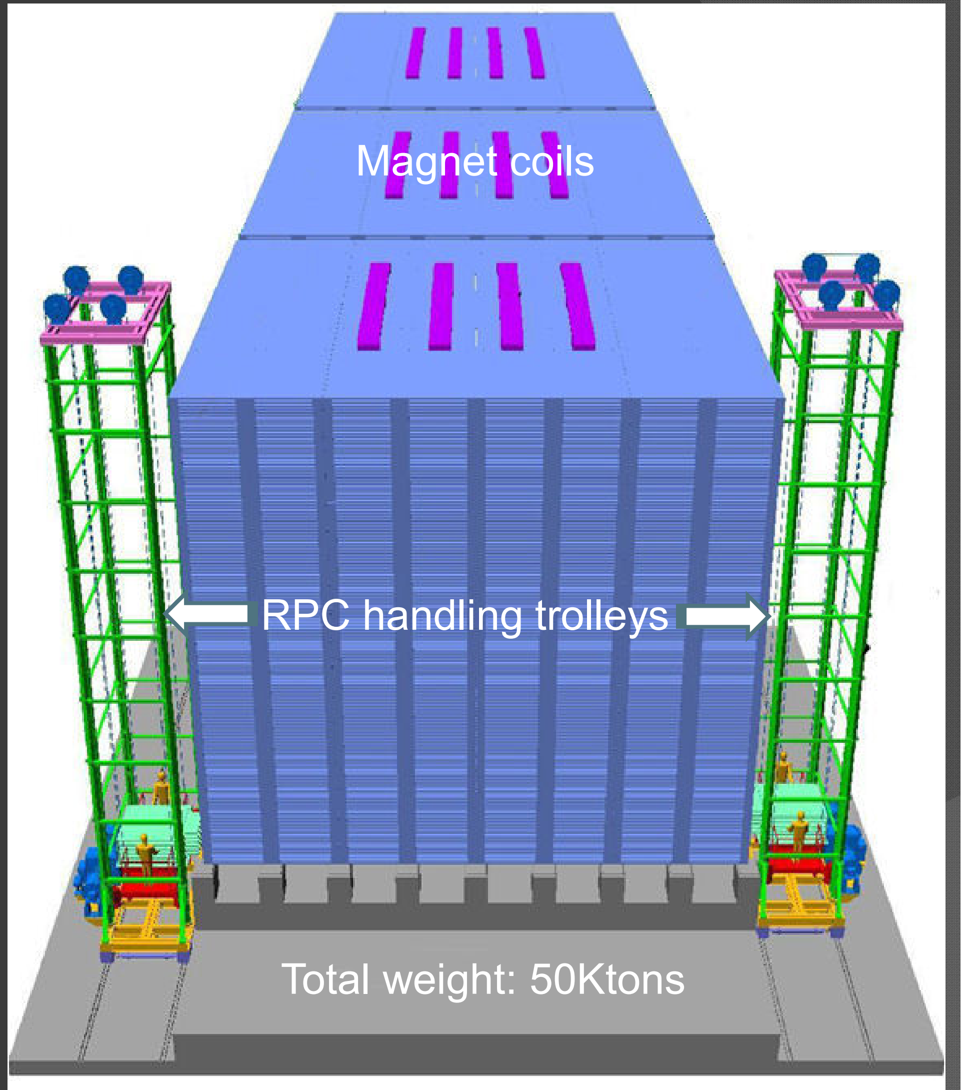
- Using atmospheric neutrinos as the source
  - Reconfirm atmospheric neutrino oscillation
  - Improved measurement of oscillation parameters
  - Search for potential matter effect in neutrino oscillation
  - Determining the sign of Δm^2_{23} using matter effect
  - Measuring deviation from maximal mixing for θ_{23}
  - Probing CP and CPT violation
  - Constraining long range leptonic forces
  - Ultra high energy neutrinos and muons
- Beam from neutrino factories
  - 7,100km from CERN – Magic baseline distance!

Detector requirements and choice

- Should have large target mass (50-100 kTons)
- Good tracking and energy resolution (tracking calorimeter)
- Good directionality (~1ns time resolution)
- Charge identification capability (magnetic field)
- Modularity and ease of construction
- Compliment capabilities of existing and proposed detectors
- Cost and time considerations
- Use magnetised iron as target mass and RPC as the active detector medium

INO cavern and the ICAL detector

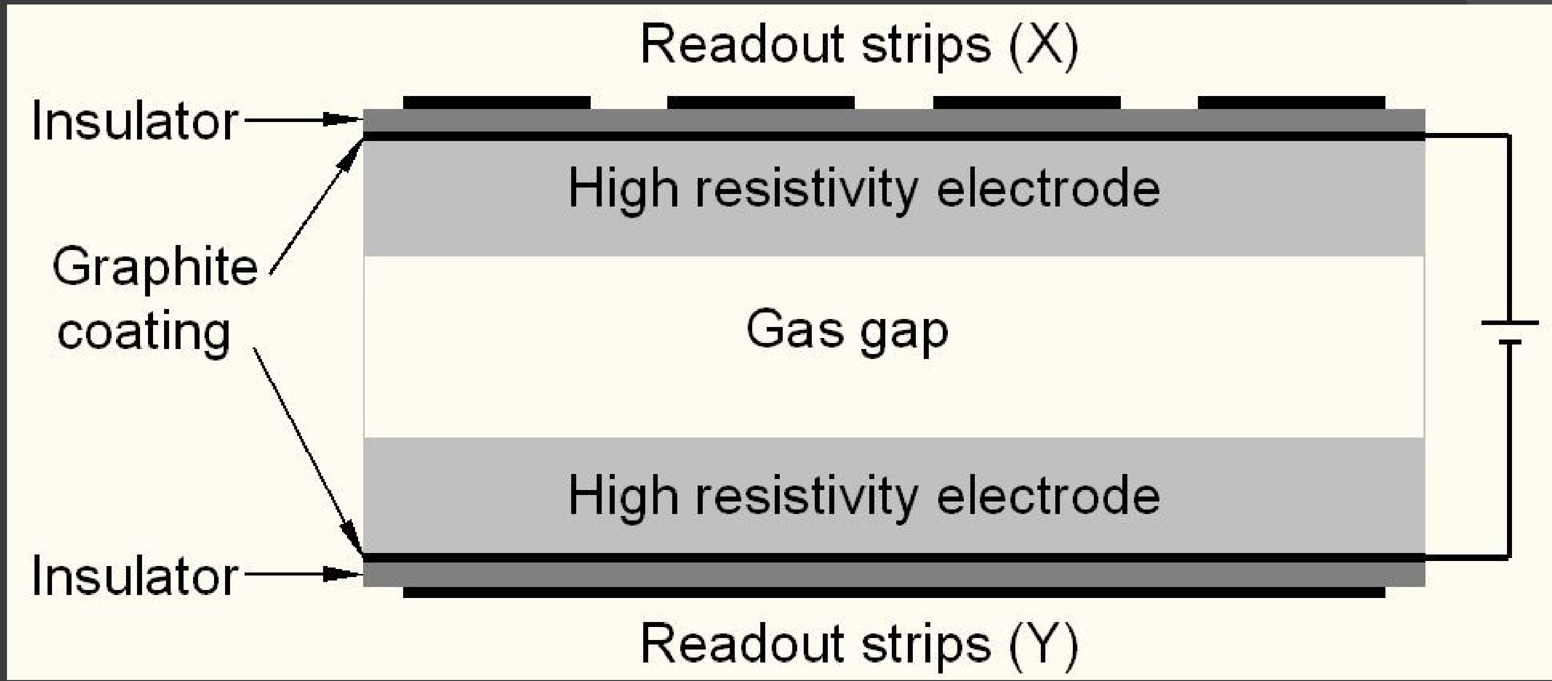




Factsheet of ICAL detector

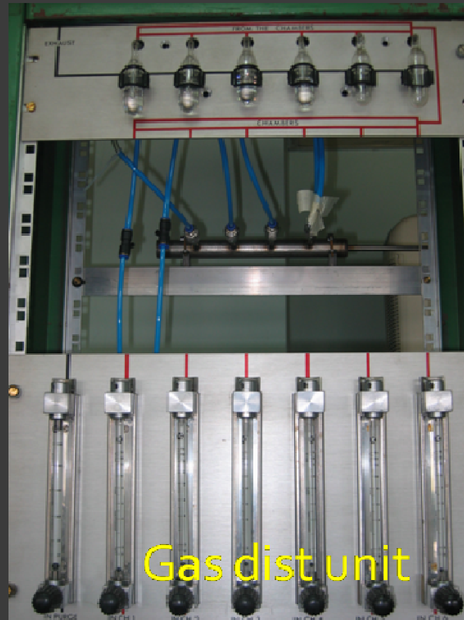
No. of modules	3
Module dimensions	16m × 16m × 14.5m
Detector dimensions	48.4m × 16m × 14.5m
No. of layers	150
Iron plate thickness	56mm
Gap for RPC trays	40mm
Magnetic field	1.3Tesla
RPC dimensions	1,840mm × 1,840mm × 24mm
Readout strip pitch	30mm
No. of RPCs/Road/Layer	8
No. of Roads/Layer/Module	8
No. of RPC units/Layer	192
No. of RPC units	28,800 (97,505m²)
No. of readout strips	3,686,400

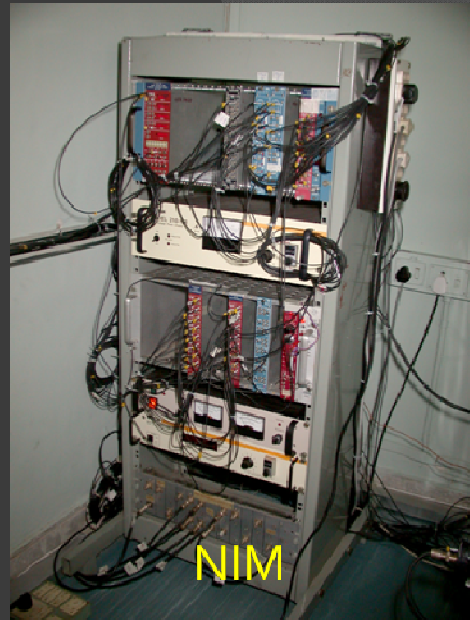
Resistive Plate Chambers (RPCs)

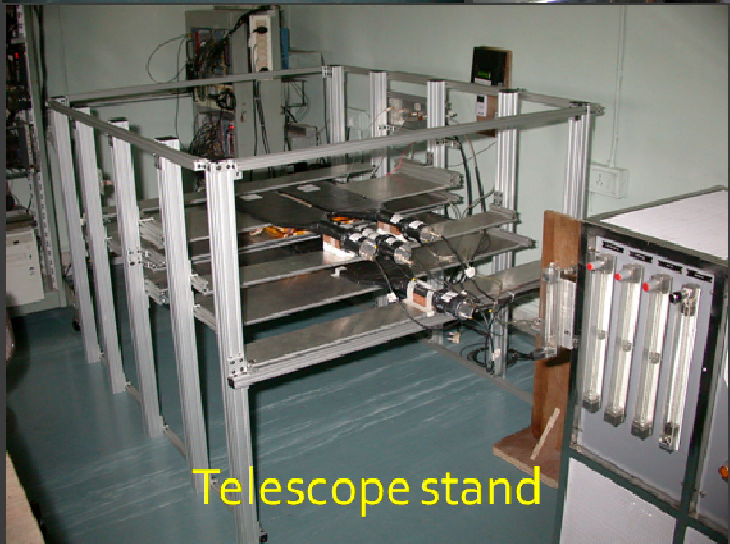


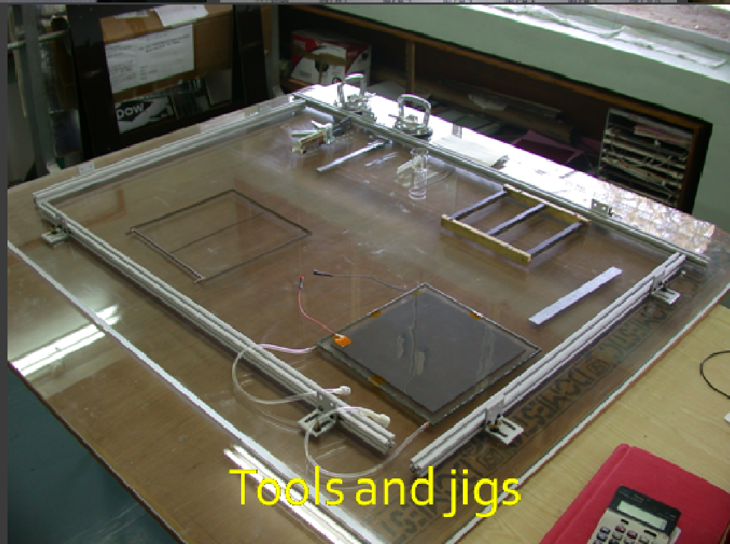
- Types of electrode (Glass and Bakelite)
- Modes of operation (Avalanche and Streamer)
- Types of construction (Single, double and multi gap)
- Types of application (Trigger and timing)

Initial infrastructure for RPC R&D

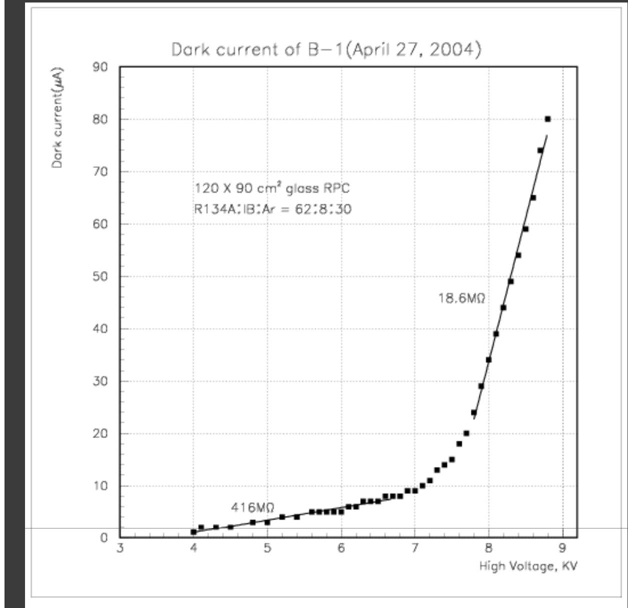


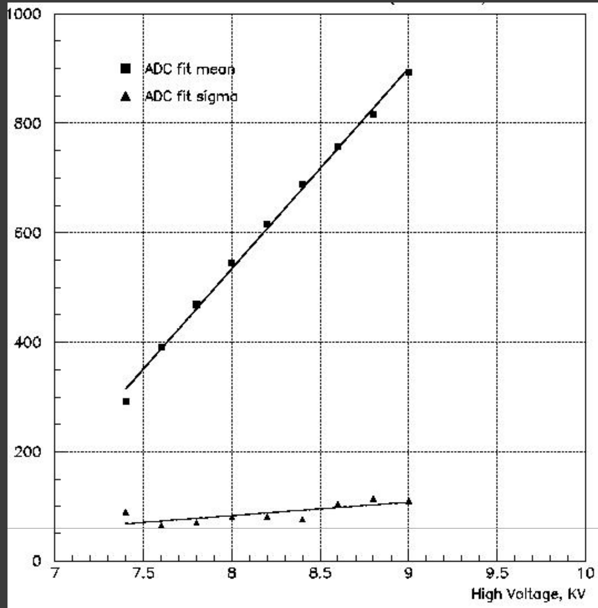


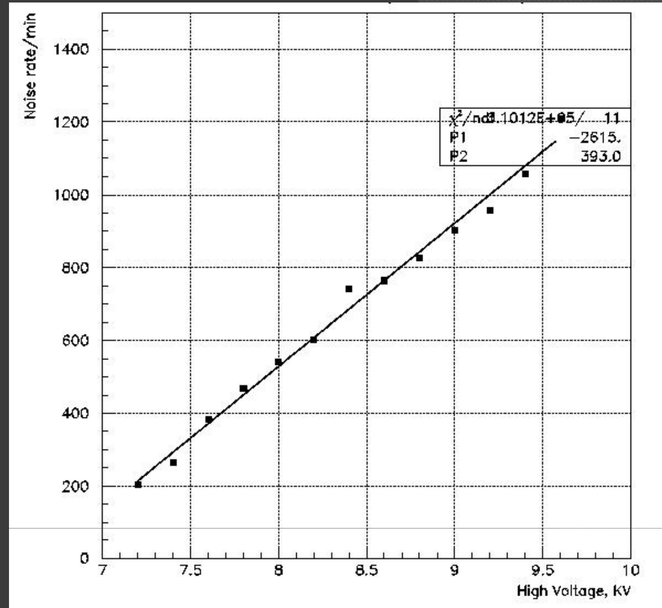


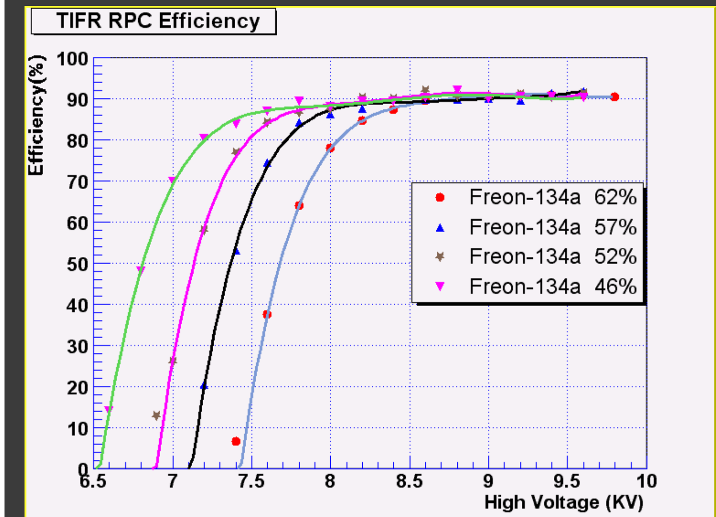


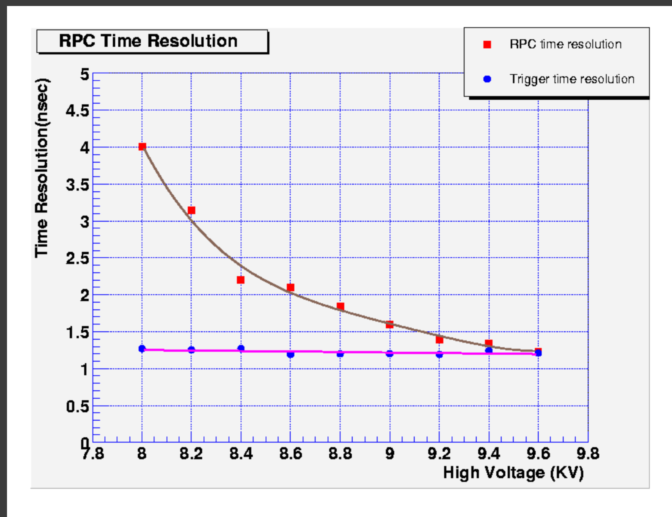
Some early *encouraging* results

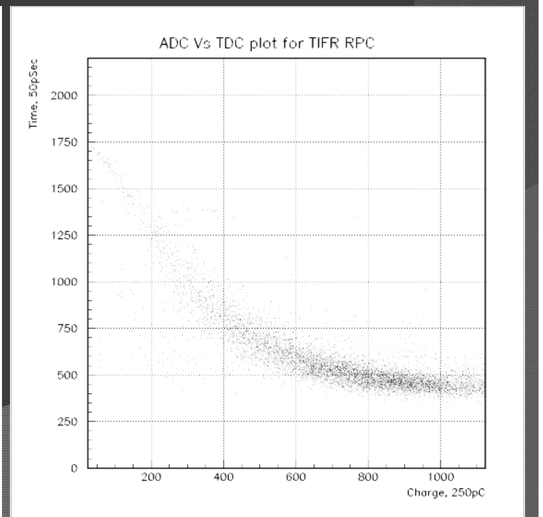










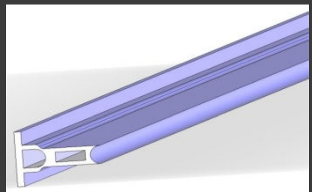


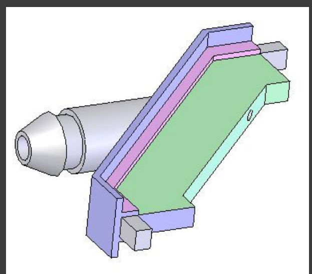
Materials & tools for RPC fabrication

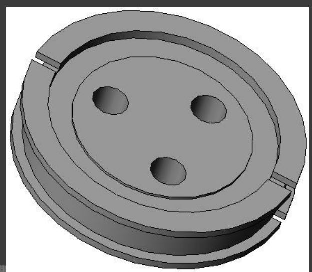
Pickup panel

Paint plant

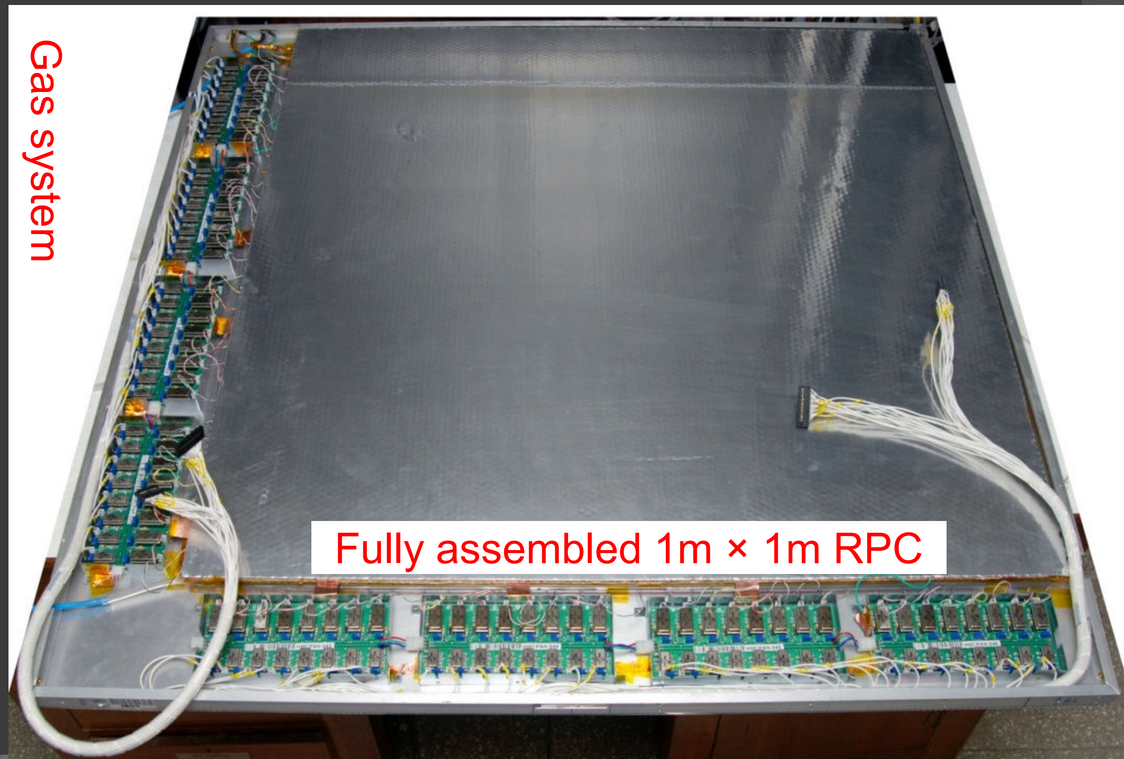
RPC Assembly jig





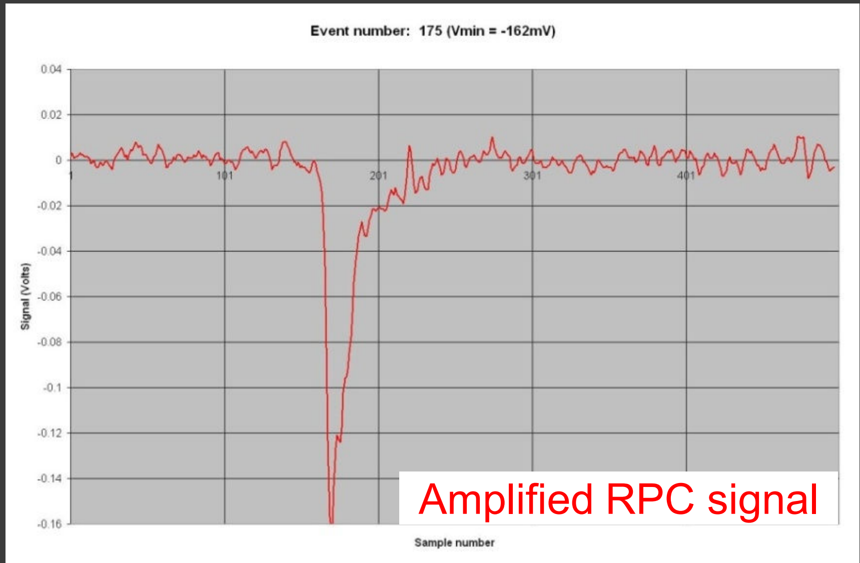


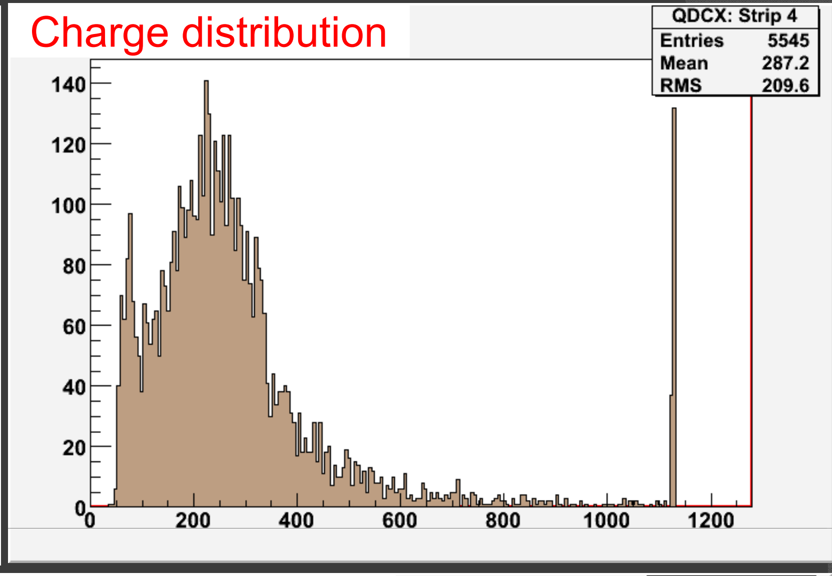
Gas system

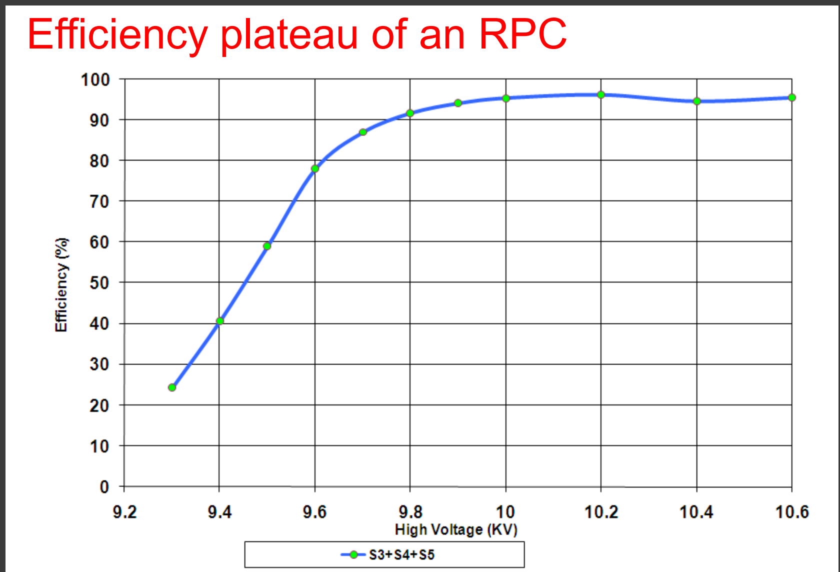


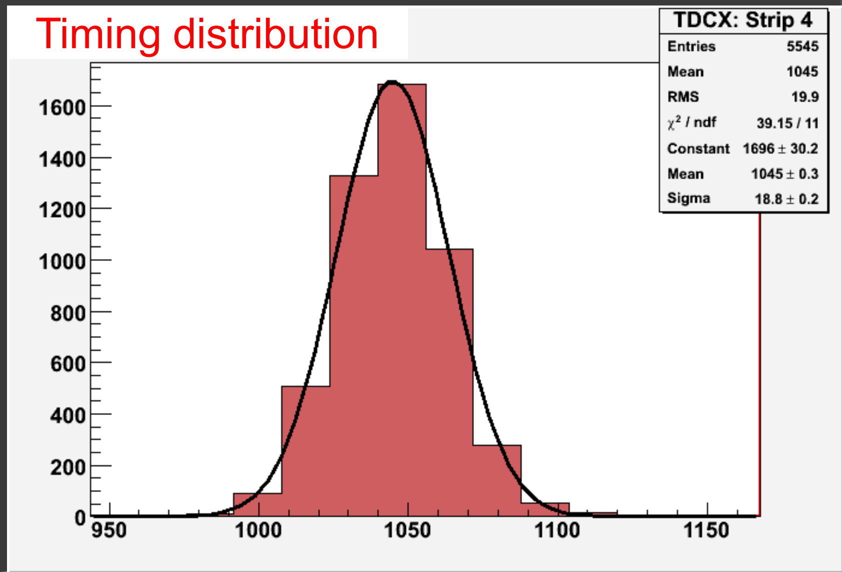
Fully assembled 1m × 1m RPC

RPC parameter characterisation

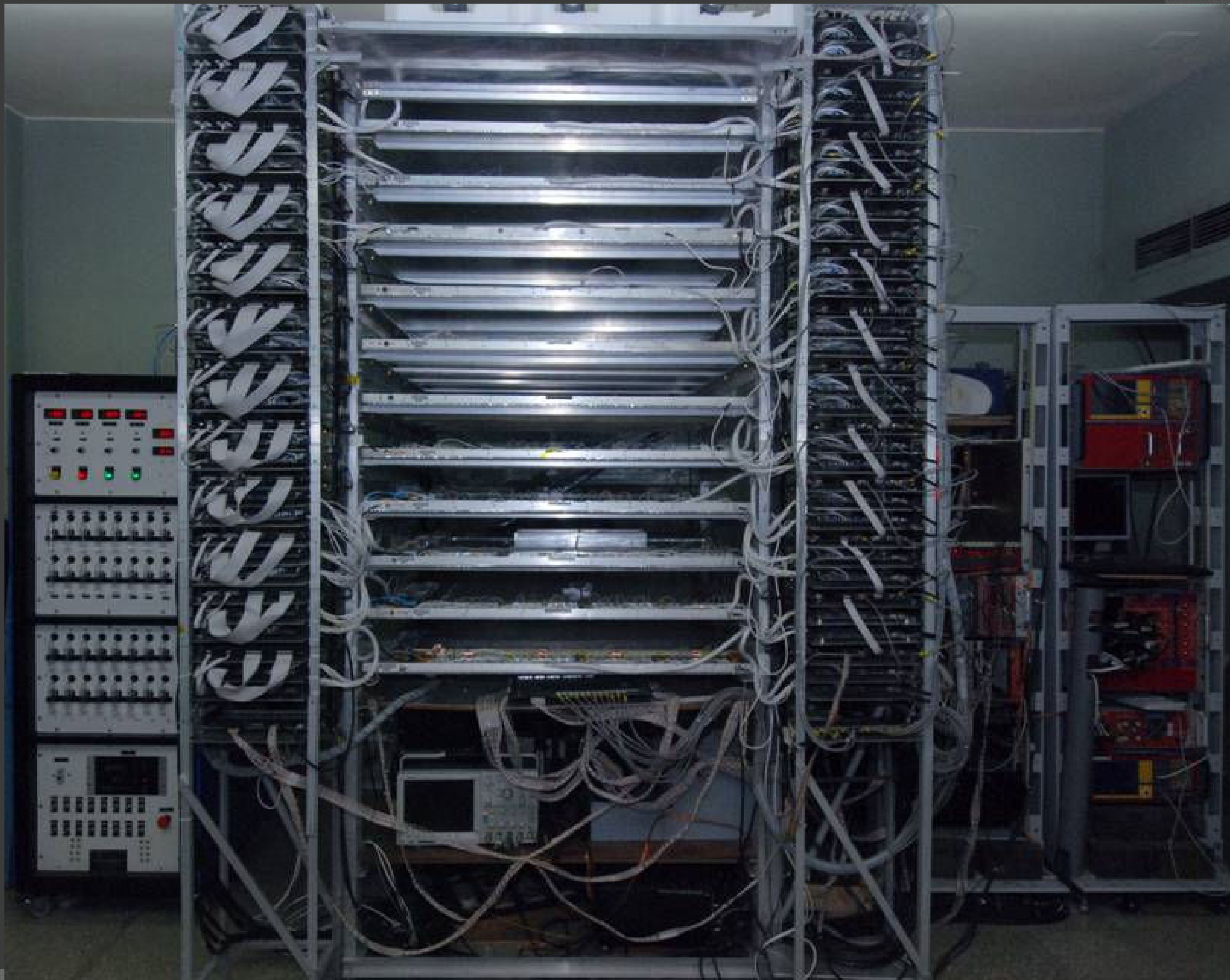






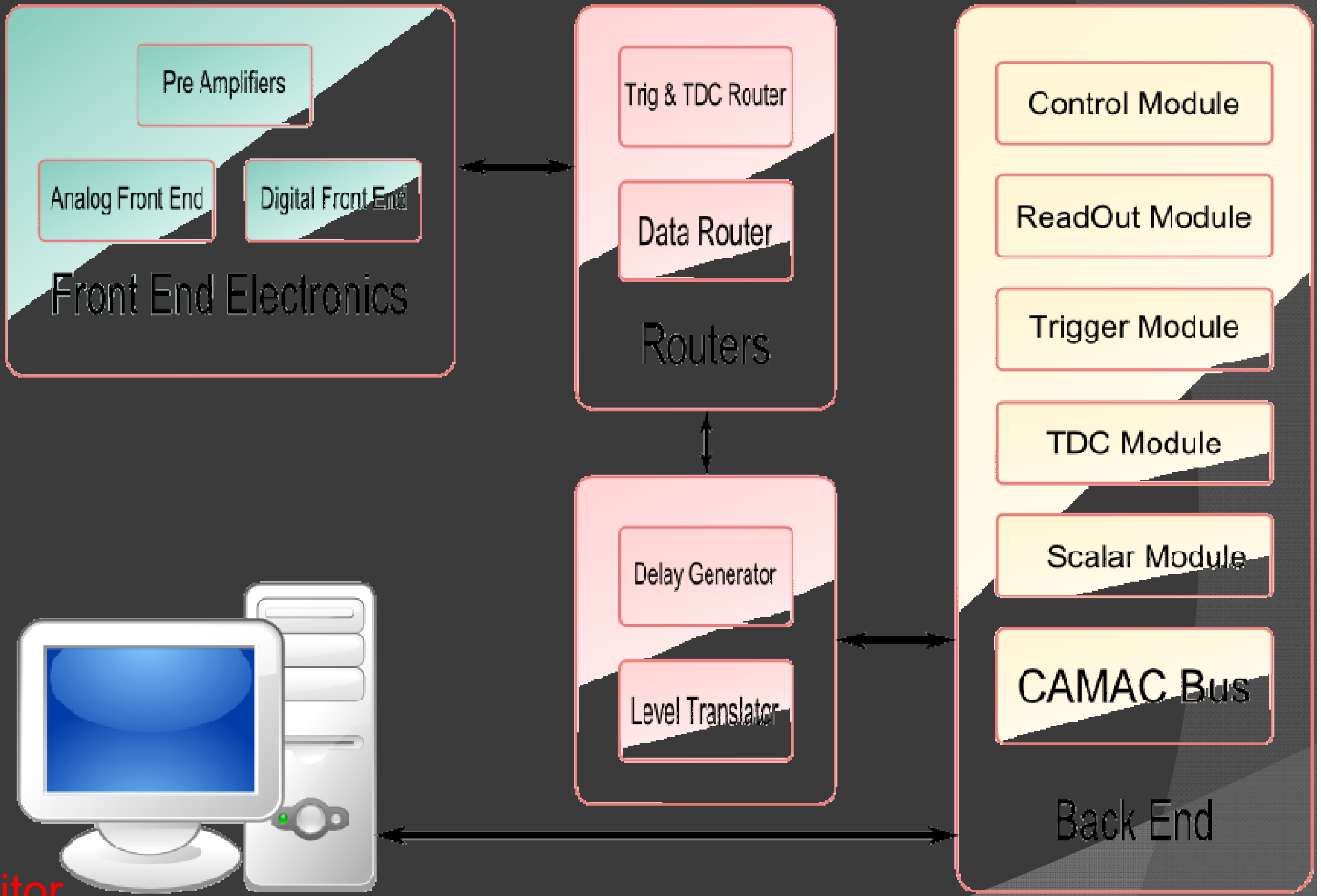


ICAL prototype RPC stack



Readout of the prototype RPC stack

- 12, $1m^2$ RPC layers
- Two readout planes
- 32 channels/plane
- 768 readout channels
- Trigger on muons using:
  - Scintillator paddle layers
  - RPC strip signals
- Recorded information:
  - Strip hits
  - Timing
- Monitoring data:
  - Chamber parameters
    - High voltage and current
    - Strip noise rates
    - Cosmic muon efficiency
  - Ambient parameters
    - Temperature
    - Relative humidity
    - Barometric pressure
- Magnet control and monitor
- Gas system control and monitor

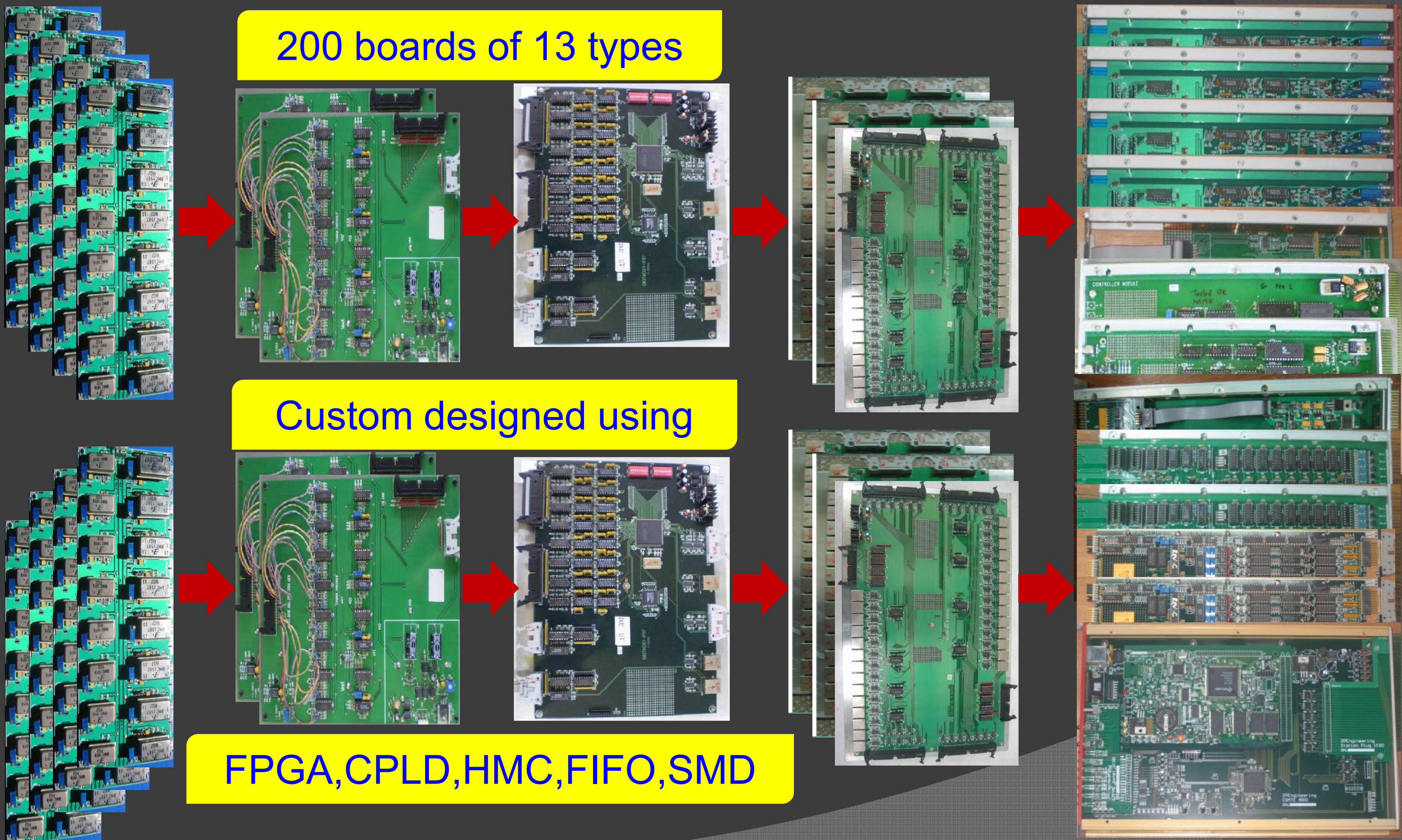


DAQ system for the prototype stack

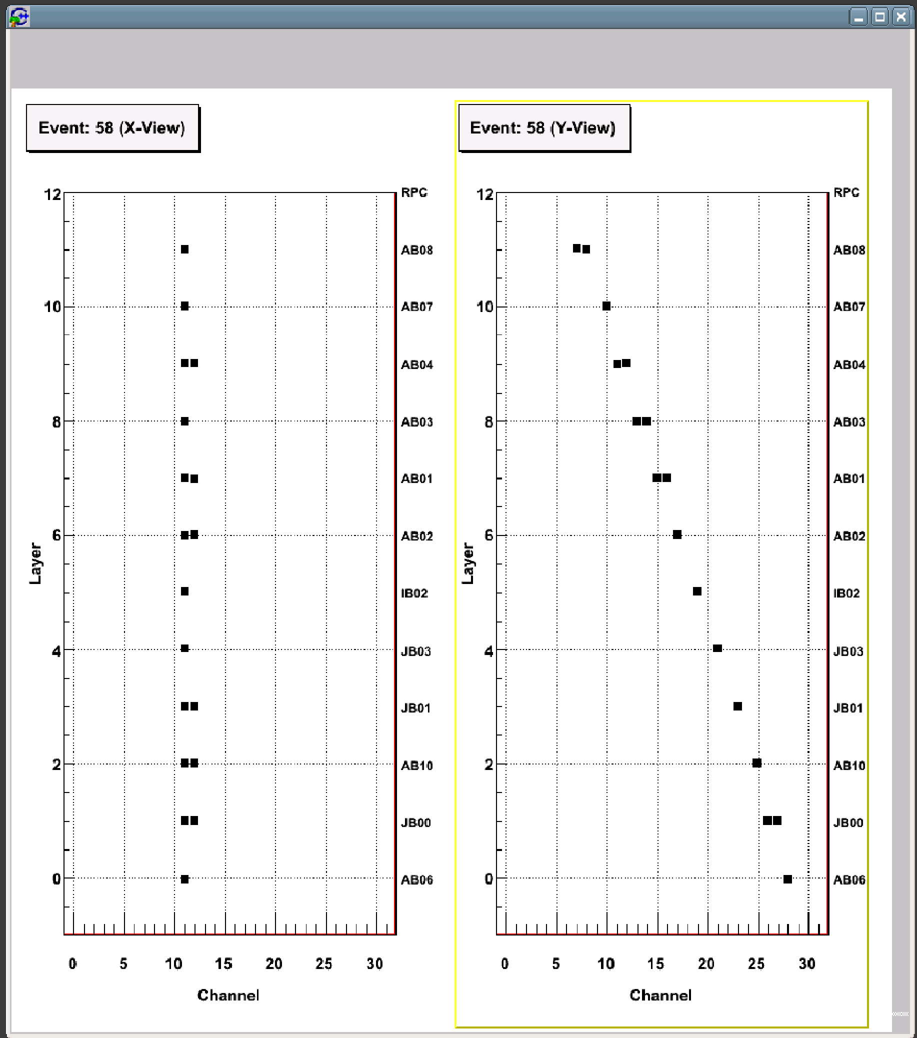
200 boards of 13 types

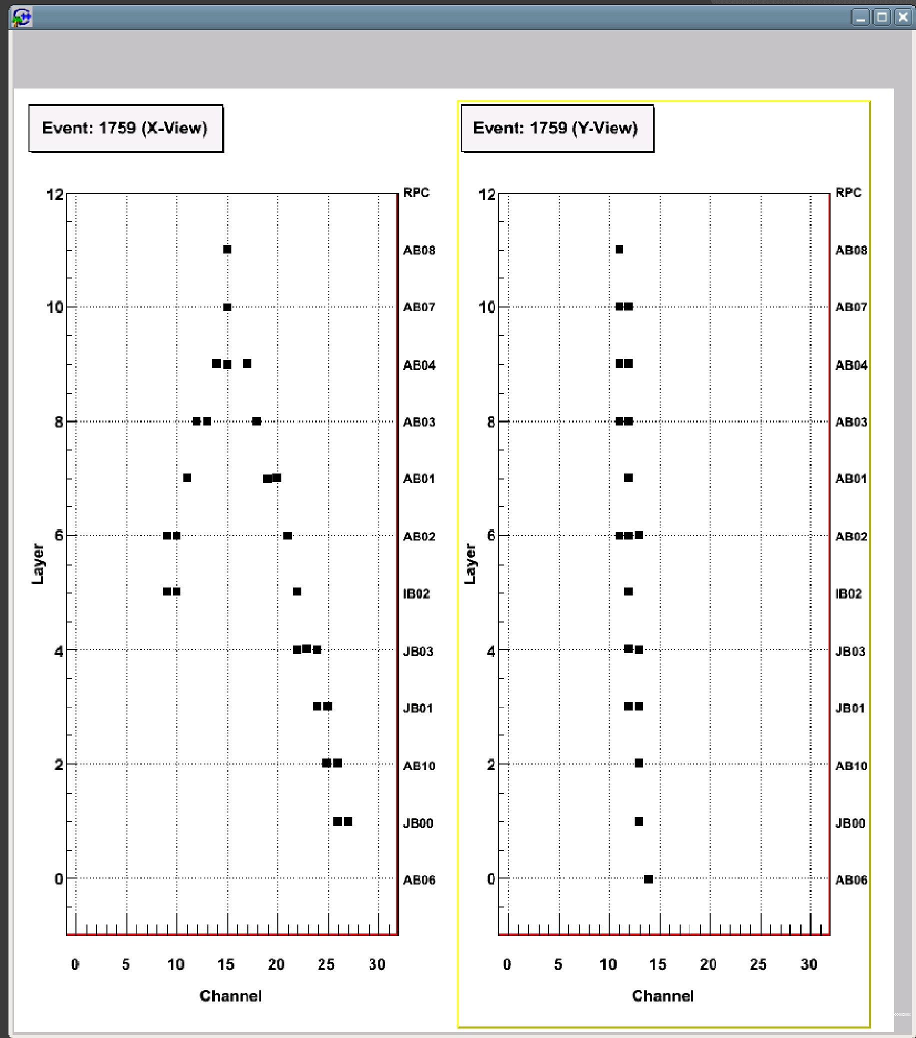
Custom designed using

FPGA,CPLD,HMC,FIFO,SMD



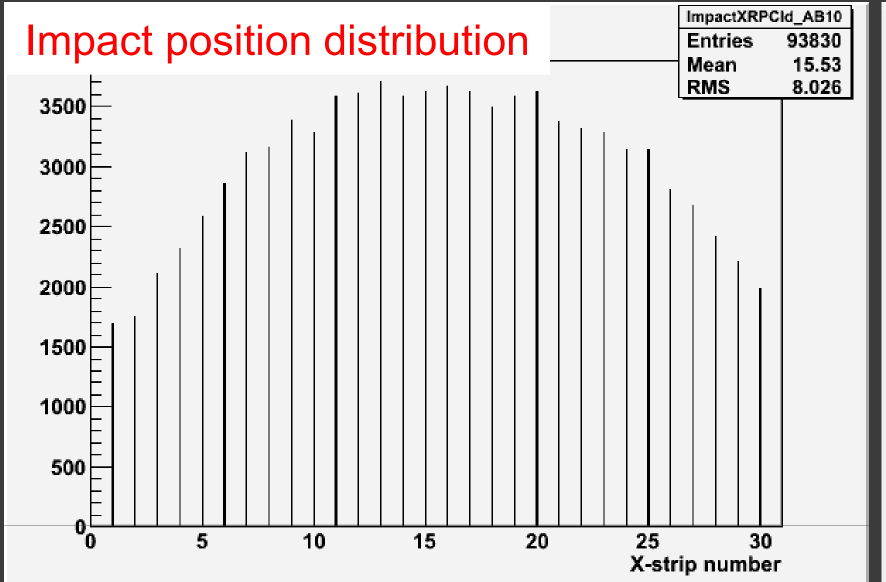
A couple of interesting events



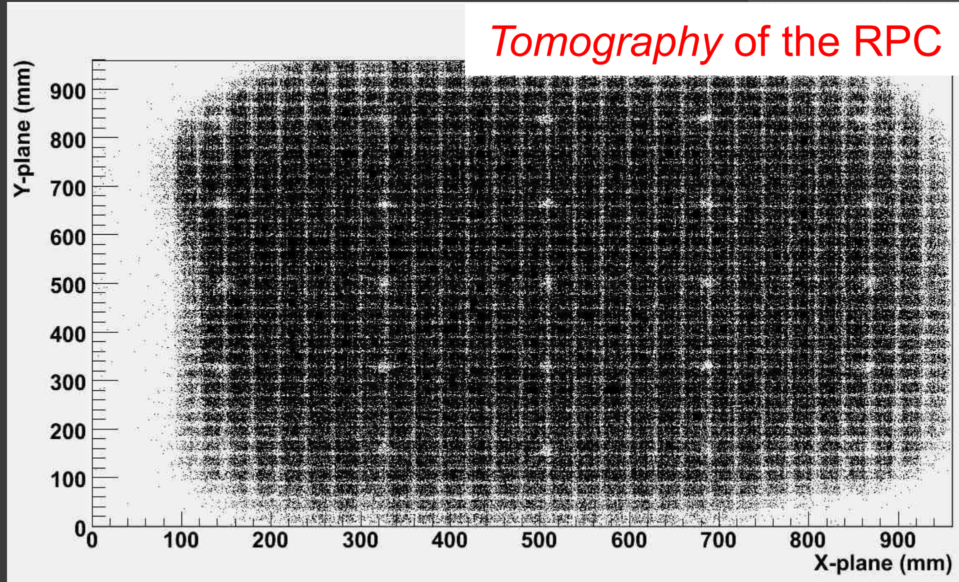


Some results from prototype stack

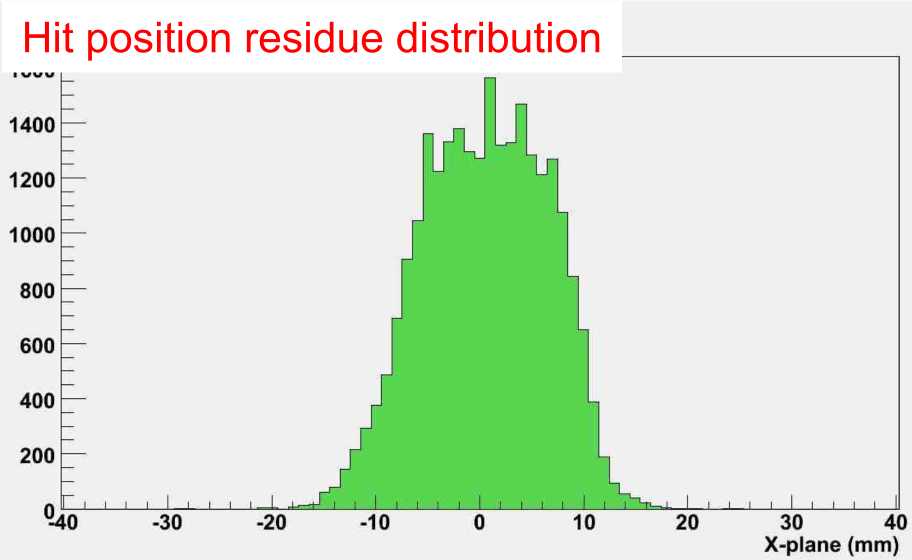
Impact position distribution



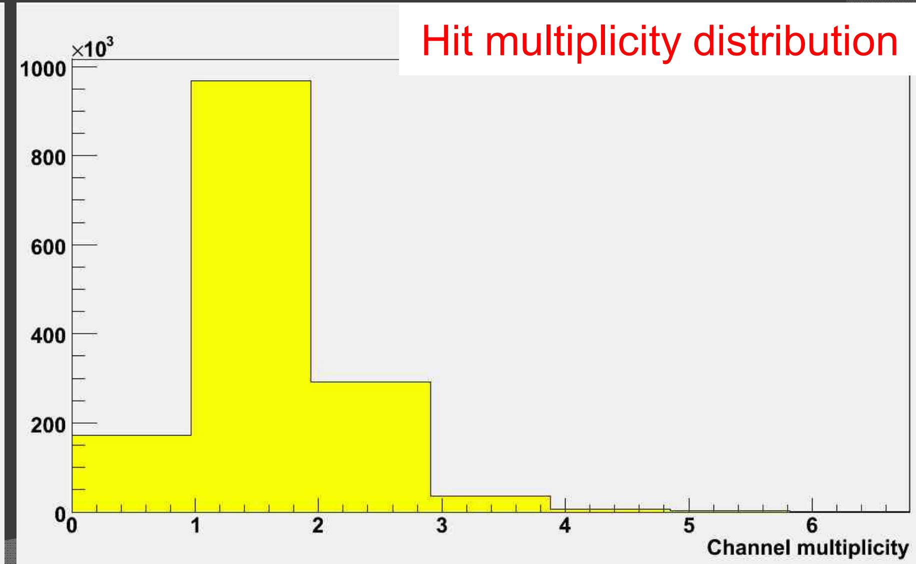
Tomography of the RPC



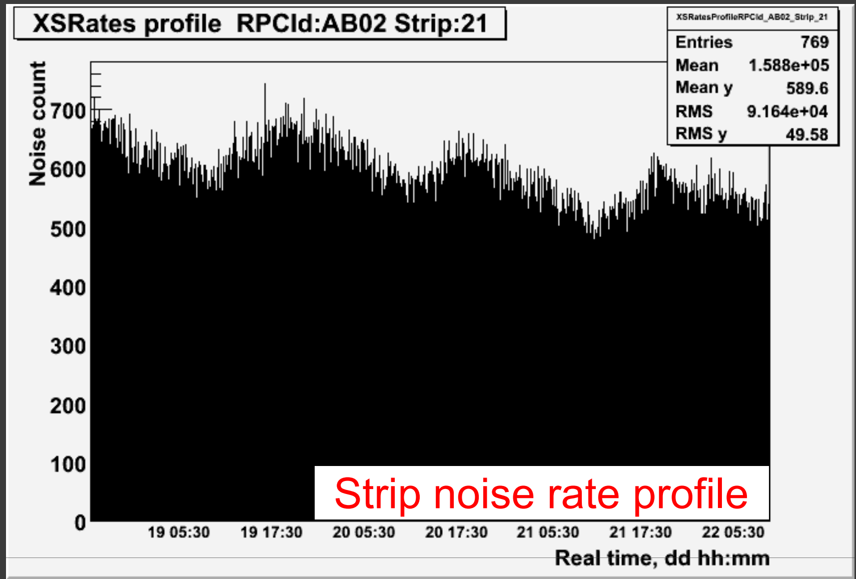
Hit position residue distribution

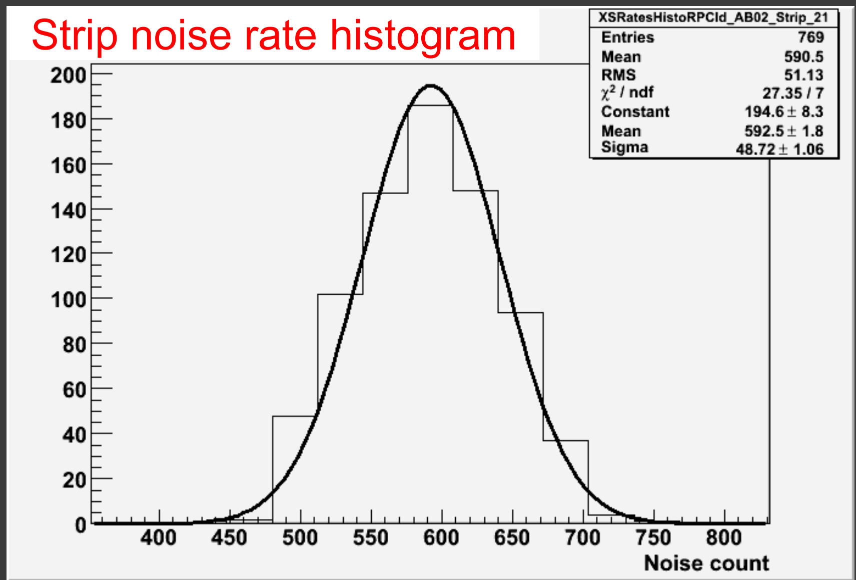


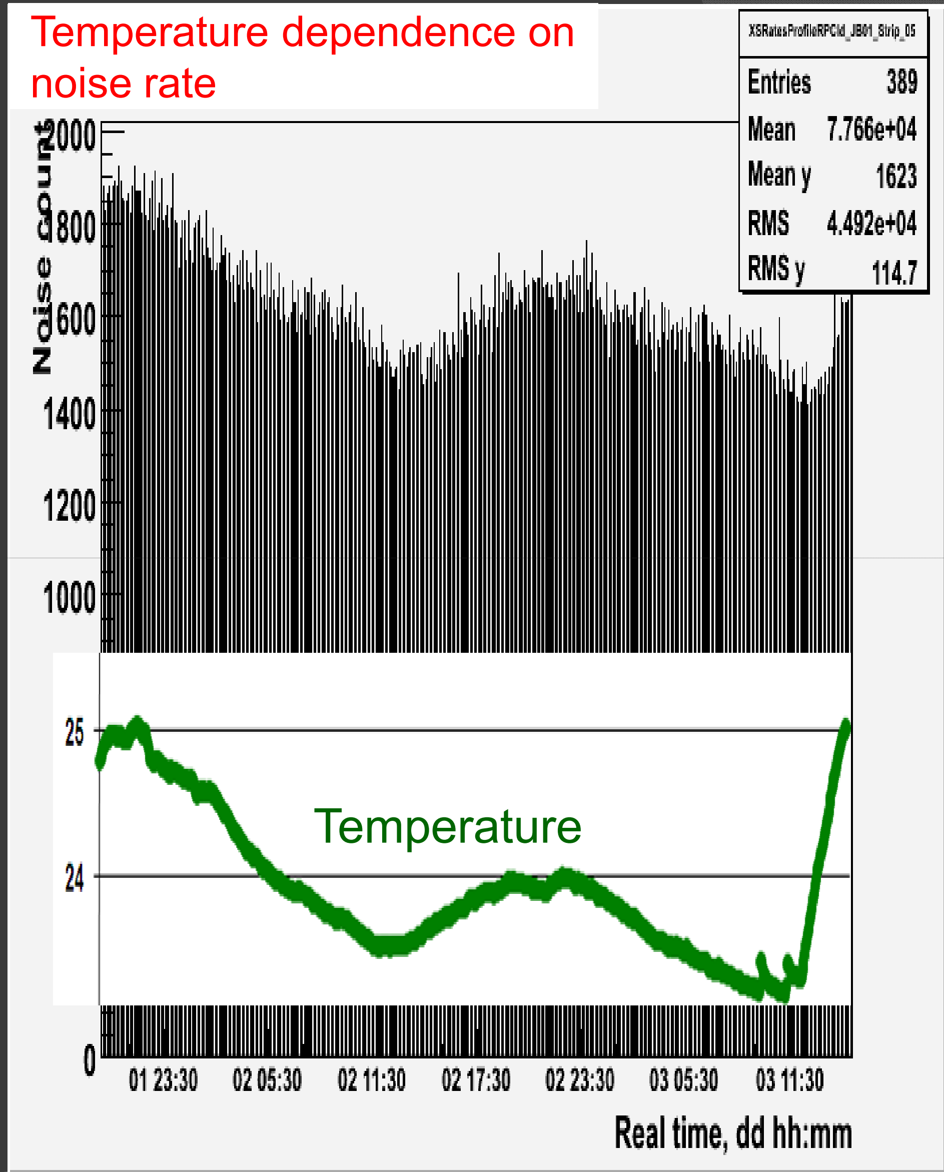
Hit multiplicity distribution



RPC strip rate monitoring





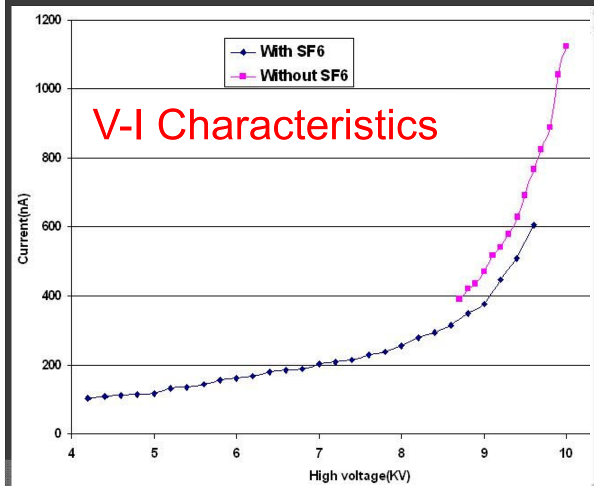


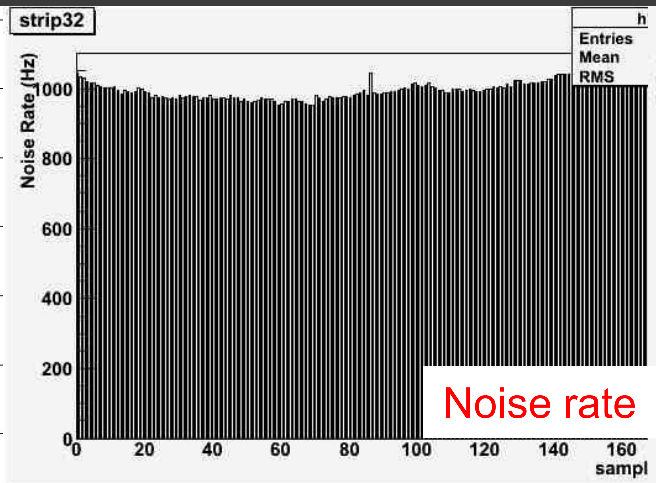
The final frontier: 2m × 2m RPCs

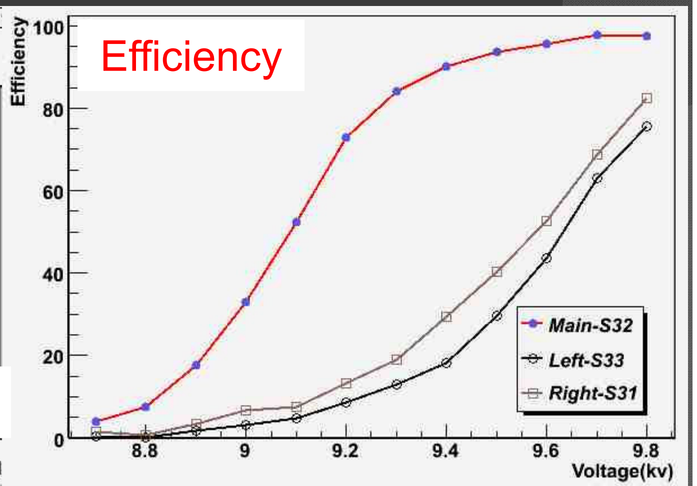
RPC fabrication stand

RPC test stand

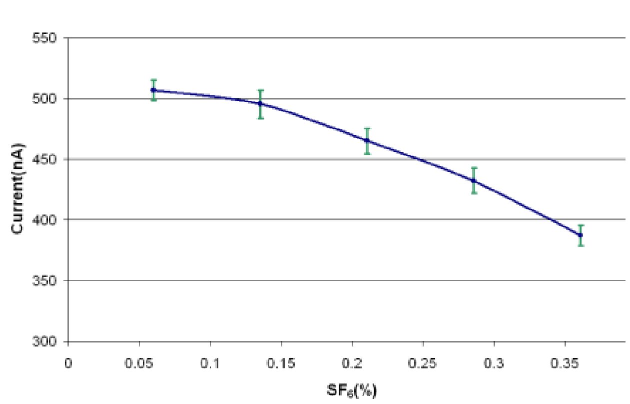
Basic characterisation of 2m × 2m RPCs



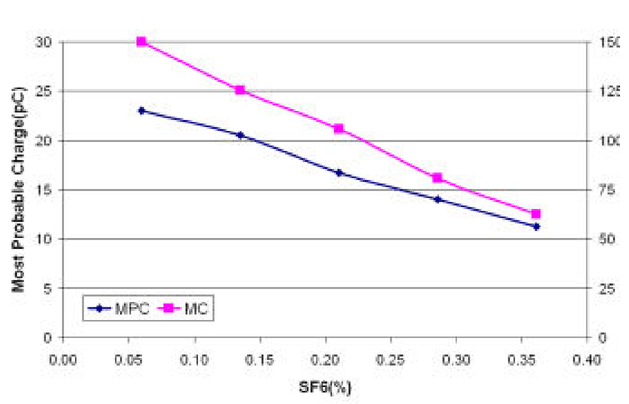




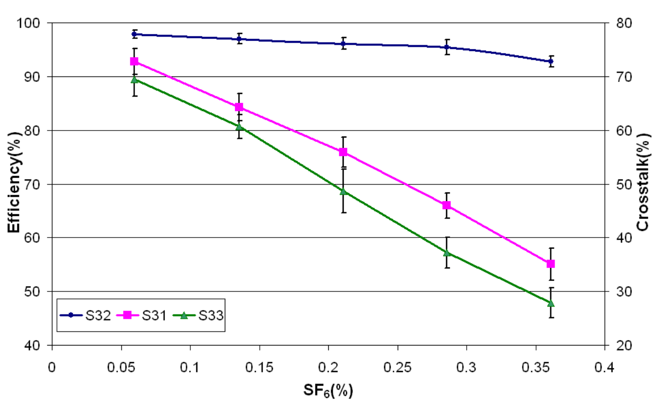
Effect of SF_6 on RPC characteristics



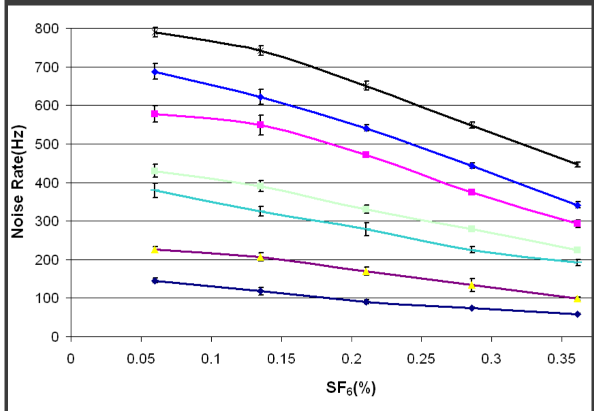
Chamber current



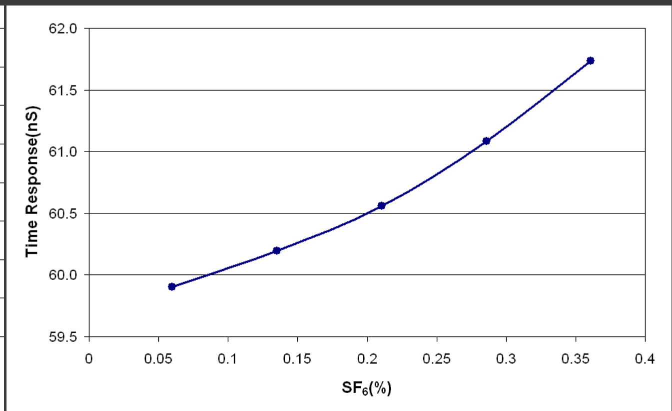
Signal charge



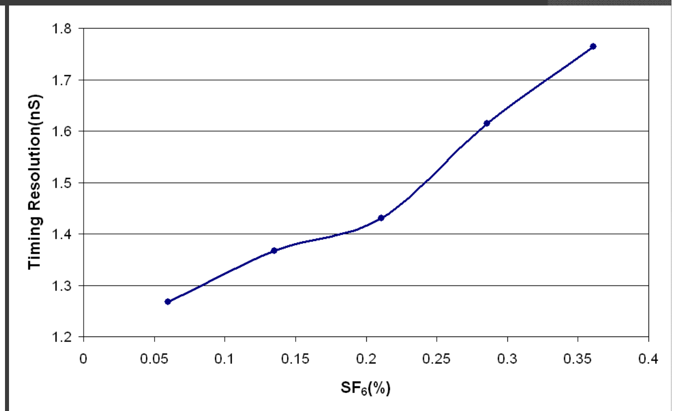
Efficiency



Noise rate



Time response



Time resolution

Summary

- INO is a jointly funded project by Department of Atomic Energy (DAE) and Department of Science and Technology (DST).
- Detailed Project Reports (DPRs) on the INO cavern and surface laboratory as well as on the ICAL detector structure are ready.
- Federal government has approved the INO project *in-principle.*
- Federal ministry of environment and forests' clearance obtained; state forest department's clearance is awaited.
- Large number of materials, processes and tools required for the RPC production were indigenously developed; a gas purification and recirculation system is under test.
- Starting from 30cm × 30cm RPCs, we have succeeded in fabrication and characterisation of 200cm × 200cm RPCs needed for ICAL detector.
- A prototype RPC stack is now operational; long-term stability tests of RPCs continuing for a couple of years.
- Tenders being floated for detailed engineering study of industrial fabrication of RPCs as well as ICAL magnet.
- Electronics and DAQ systems for the ICAL detector are being designed.