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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 $\Delta m^2_{23}$ using matter effect
  - Measuring deviation from maximal mixing for $\theta_{23}$
  - 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

Vertical rock coverage: 1300m

Total weight: 50Ktons
# Factsheet of ICAL detector

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of modules</td>
<td>3</td>
</tr>
<tr>
<td>Module dimensions</td>
<td>$16m \times 16m \times 14.5m$</td>
</tr>
<tr>
<td>Detector dimensions</td>
<td>$48.4m \times 16m \times 14.5m$</td>
</tr>
<tr>
<td>No. of layers</td>
<td>150</td>
</tr>
<tr>
<td>Iron plate thickness</td>
<td>56mm</td>
</tr>
<tr>
<td>Gap for RPC trays</td>
<td>40mm</td>
</tr>
<tr>
<td>Magnetic field</td>
<td>1.3 Tesla</td>
</tr>
<tr>
<td>RPC dimensions</td>
<td>$1,840mm \times 1,840mm \times 24mm$</td>
</tr>
<tr>
<td>Readout strip pitch</td>
<td>30mm</td>
</tr>
<tr>
<td>No. of RPCs/Road/Layer</td>
<td>8</td>
</tr>
<tr>
<td>No. of Roads/Layer/Module</td>
<td>8</td>
</tr>
<tr>
<td>No. of RPC units/Layer</td>
<td>192</td>
</tr>
<tr>
<td>No. of RPC units</td>
<td>28,800 ($97,505m^2$)</td>
</tr>
<tr>
<td>No. of readout strips</td>
<td>3,686,400</td>
</tr>
</tbody>
</table>
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

Gasmixing unit
Gas filter unit
Gas dist unit
NIM
Telescope stand
Tools and jigs
CAMAC
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

Amplified RPC signal

Charge distribution

Efficiency plateau of an RPC

Timing distribution
Readout of the prototype RPC stack

12, 1m² 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

Strip noise rate profile

Temperature dependence on noise rate

Temperature

Strip noise rate histogram
The final frontier: 2m × 2m RPCs

Basic characterisation of 2m × 2m RPCs

V-I Characteristics

RPC fabrication stand

RPC test stand

Noise rate

Efficiency
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.