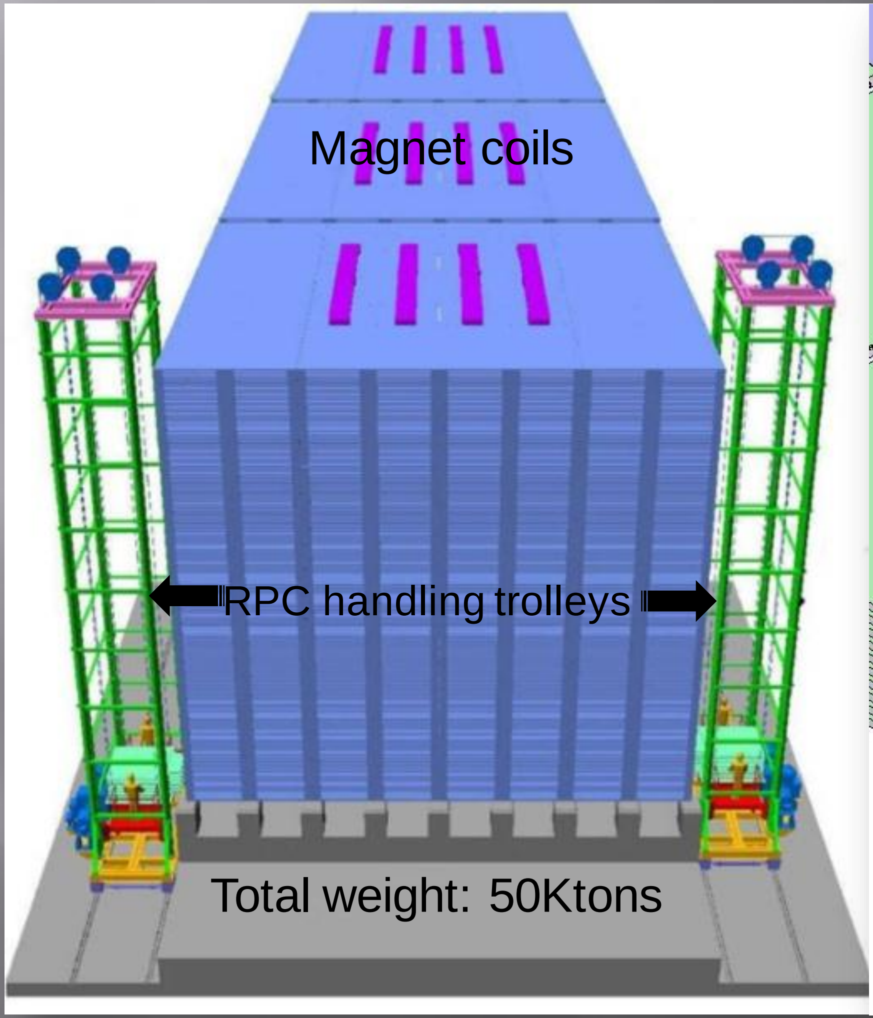
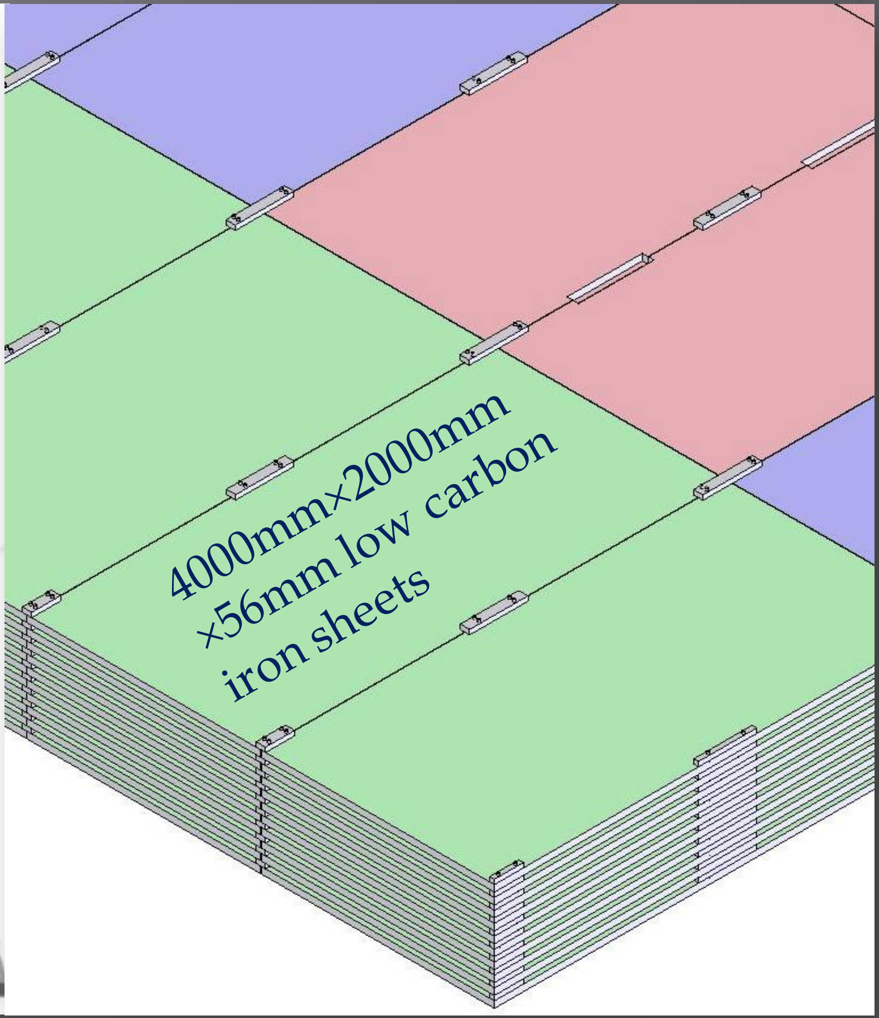
ARE WE READY WITH RPCS FOR ICAL?

B.Satyanarayana, TIFR, Mumbai

ICAL detector and construction

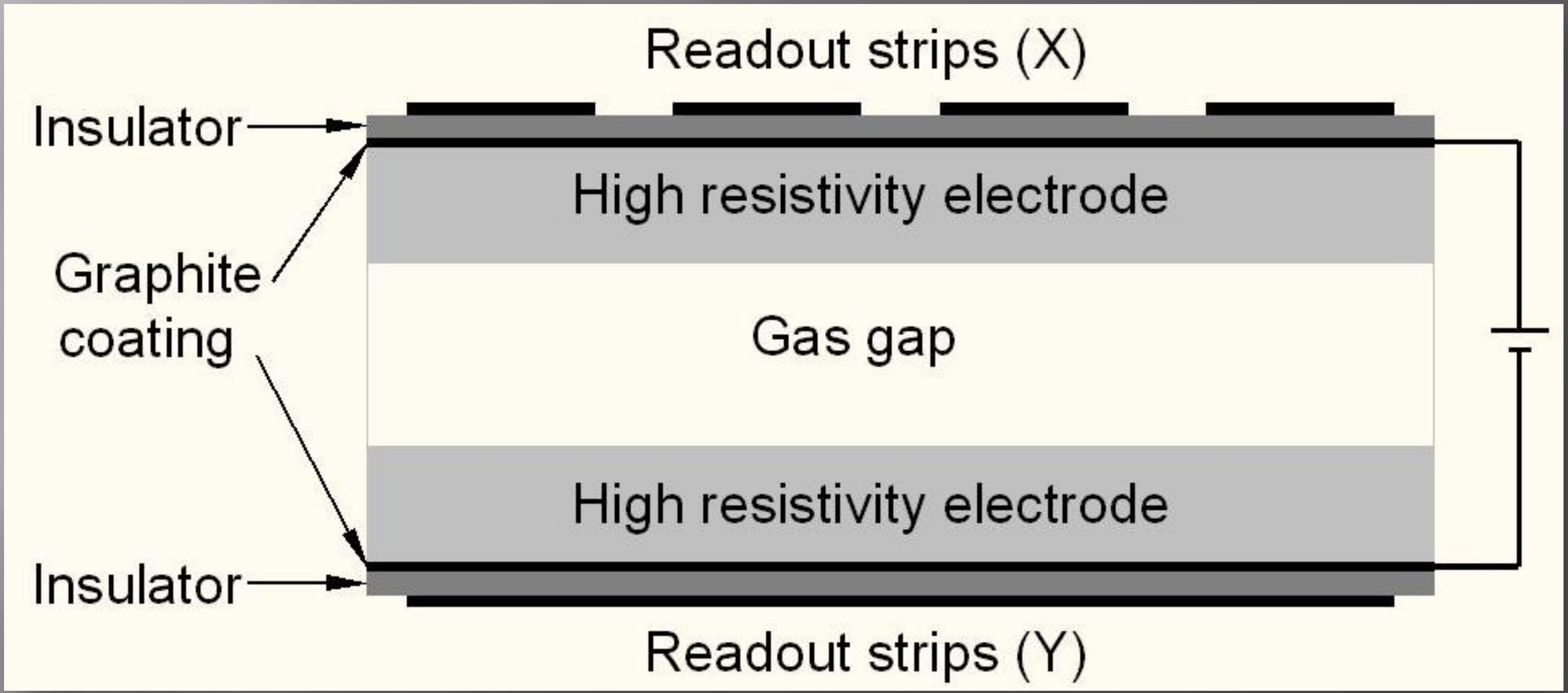




Factsheet of ICAL detector

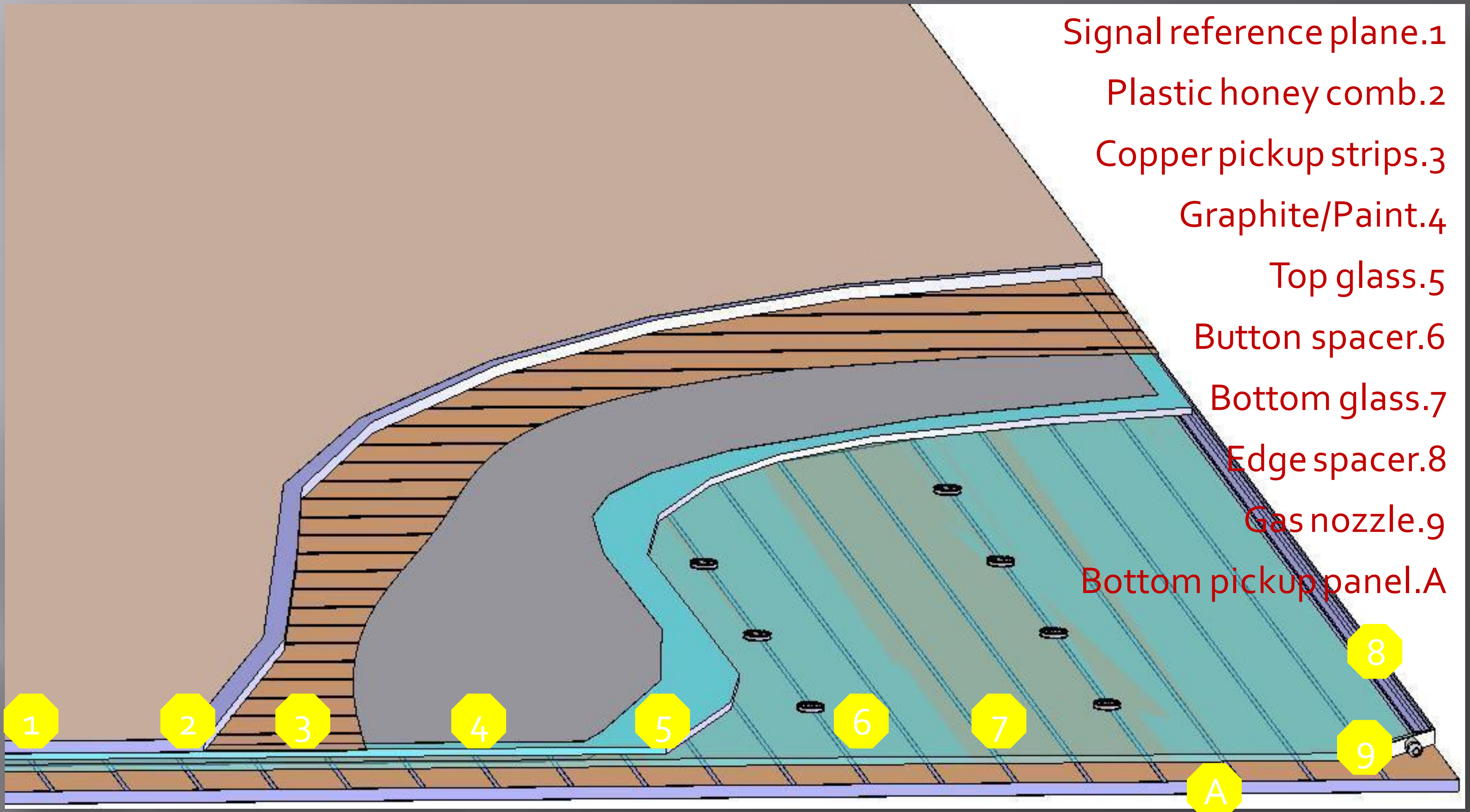
No. of modules	3
Module dimensions	16m × 16m × 14.5m
Detector dimensions	48.4m × 16m × 14.5m
No. of layers	150
Iron plate thickness	56mm
Gap for RPC trays	40mm
Magnetic field	1.3Tesla
RPC dimensions	1,950mm × 1,840mm × 26mm
Readout strip pitch	30mm
No. of RPCs/Road/Layer	8
No. of Roads/Layer/Module	8
No. of RPC units/Layer	192
No. of RPC units	28,800 (97,505m^2)
No. of readout strips	3,686,400

Schematic of a basic RPC



- ❖ Glass (bakelite) for electrodes
- ❖ Special paint mixture for semi-resistive coating
- ❖ Plastic honey-comb laminations as pick-up panel
- ❖ Special plastic films for insulation
- ❖ Avalanche (streamer) mode of operation
- ❖ Gas: R134a+Iso-butane+SF_6 = 95.5+4.2+0.3 (R134a+Iso-butane+Argon=56+7+37)

Construction of an RPC detector



Glass electrode preparation

Glass cleaning

- Cleaned with *Labolene* soap solution and rinsed with distilled water
- Left to natural drying
- Wiped with iso-propyl alcohol

Spray painting

- Using auto garage compressor and paint spray gun
- Left to natural drying
- Currently scaling-up an automated paint plant used for 1m x 1m glass

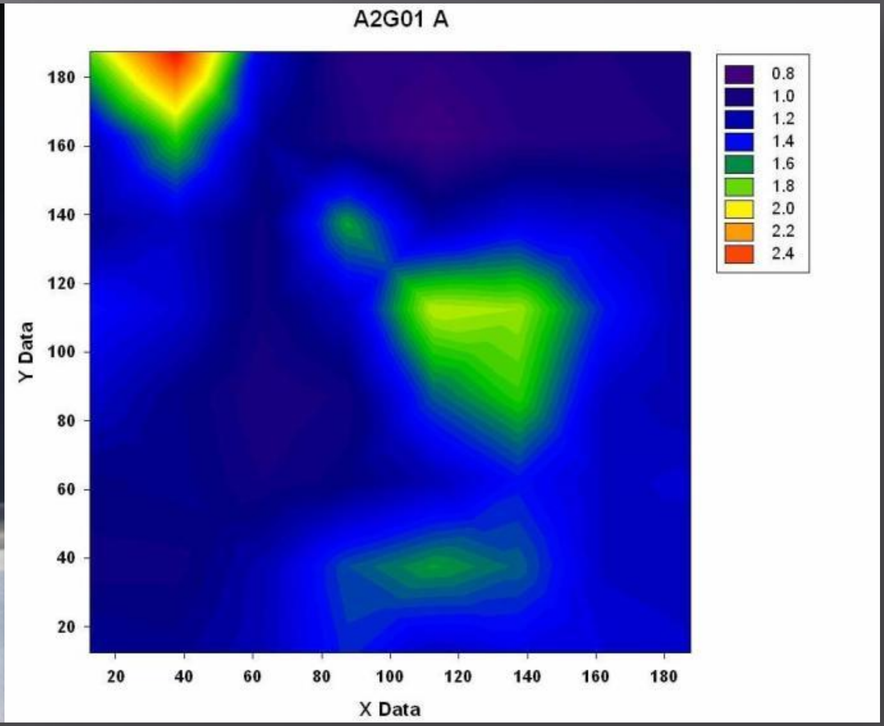
Surface resistivity measurement

Measurement jig

- Developed a simple technique
- Fabricated jigs of various sizes to suit for measurements of different grid sizes

Measurement data

- *Reasonably* uniform
- Needs improvement at the edges
- Better uniformity obtained on sheets painted by automatic paint plant



Gas gap preparation-1

Bottom glass in place

- Template for button positions placed below the bottom glass
- Buttons placed on 20cm x 20cm grid

Gluing of buttons

- Currently glue dispensed manually
- Protective template placed on the glass
- Auto timer-based glue dispenser being designed

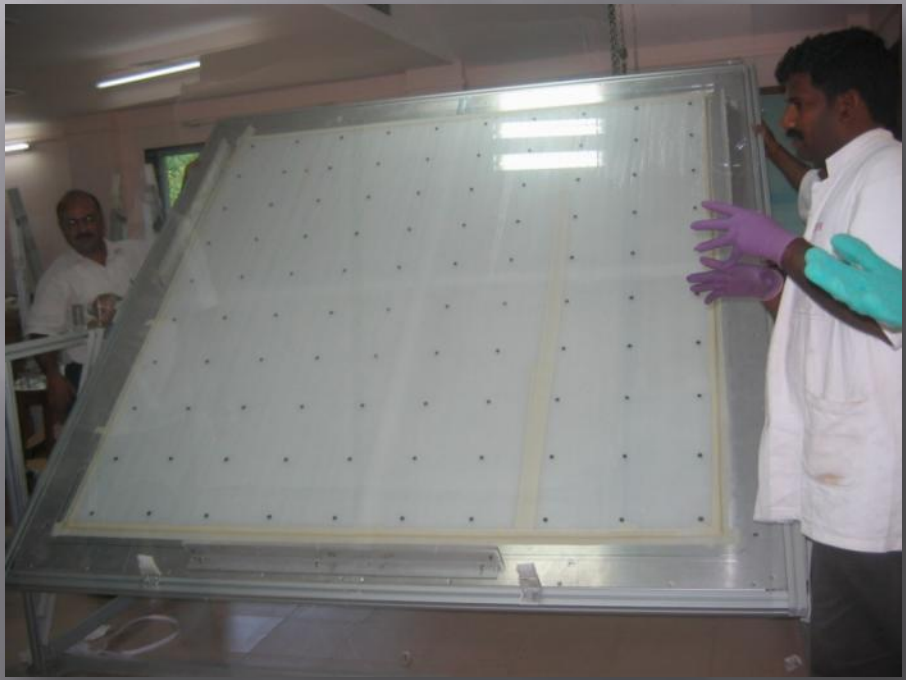
Gas gap preparation-2

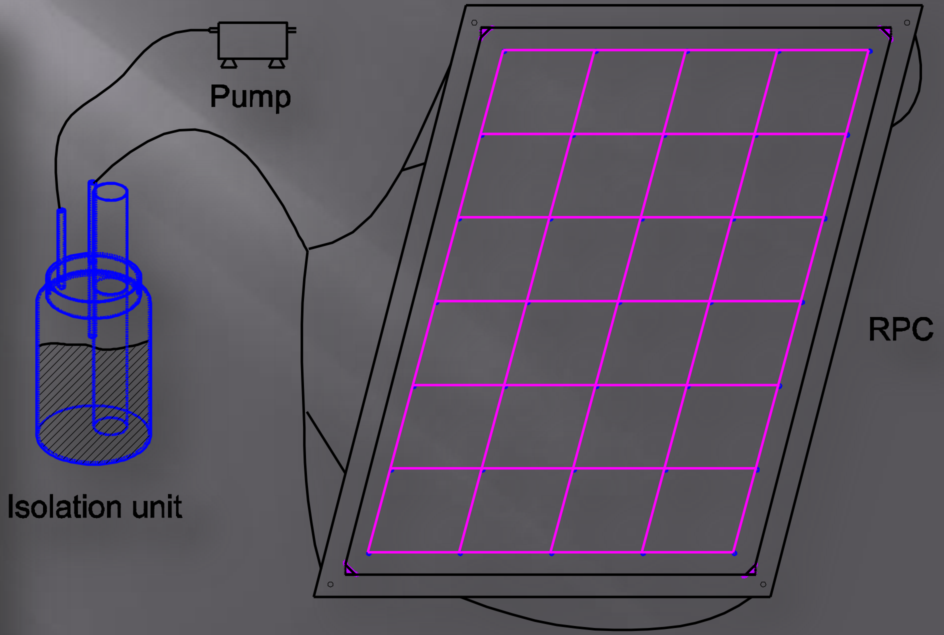
Placing the top glass

- Tilting the work table for placing the top glass electrode
- Precise stoppers mounted on the table for guiding the top glass

Vacuum jig for gluing

- A simple vacuum jig designed for perfect and efficient gluing of the gas gap
- Technique suggested by Carlo Gustavino





Gas gap preparation-3

Preparing to glue bottom-side

- Rotating the work table for gluing bottom-side spacers
- Suitable work-table design and over-head crane for easy handling of glasses and gaps

Ready to glue top-side spacers

- Last step before closing the gas gap
- Gas nozzles on all four corners of the gap – two each used for gas inlet and outlet

2mx2m RPC: preparation-4

Leak testing the gap

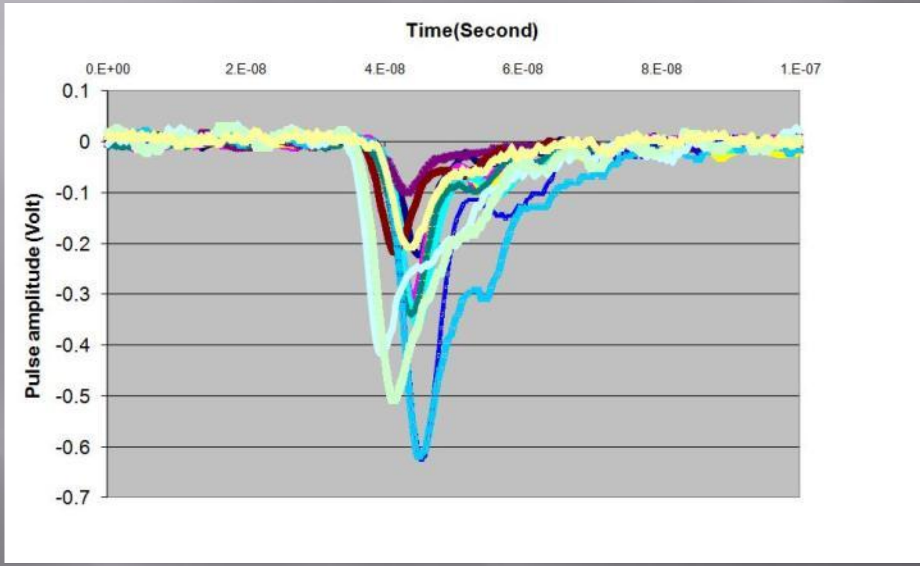
- The gap pressurised marginally above atmosphere with R134a gas
- Tested for leaks with R134a leak detector
- Leaks plugged

Fully fabricated gas gap

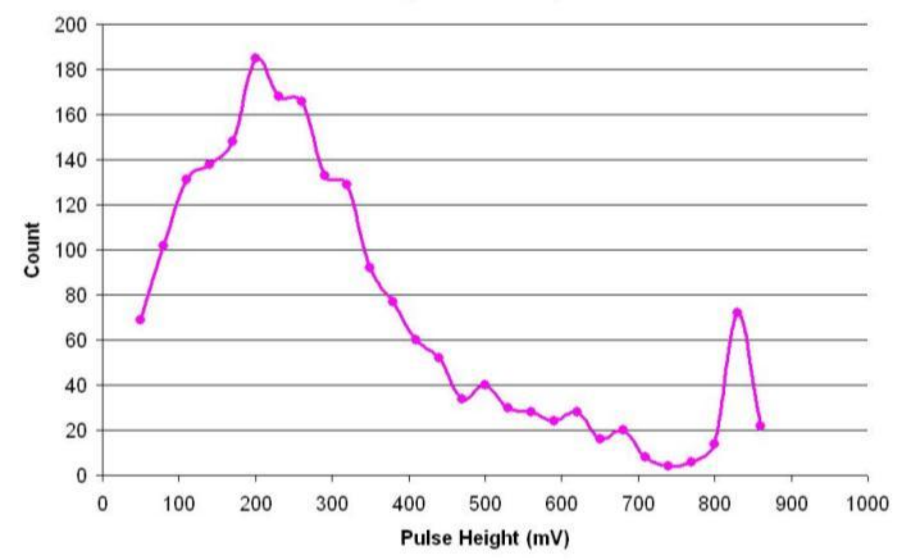
- Gap ready to be assembled as an RPC detector chamber

RPC pulse height studies

Preamplifier pulse shots



Pulse height distribution

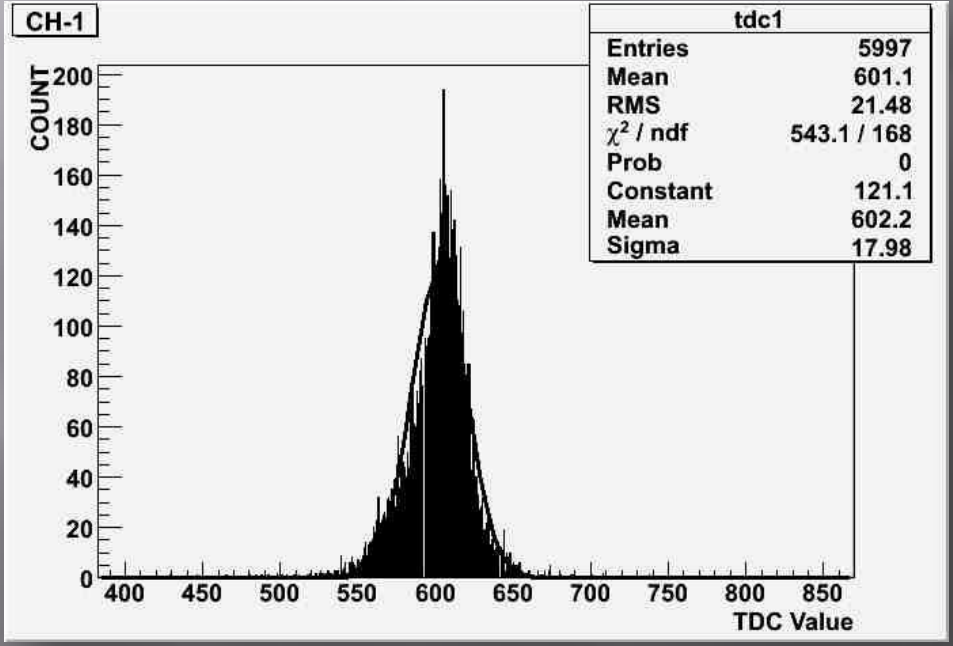


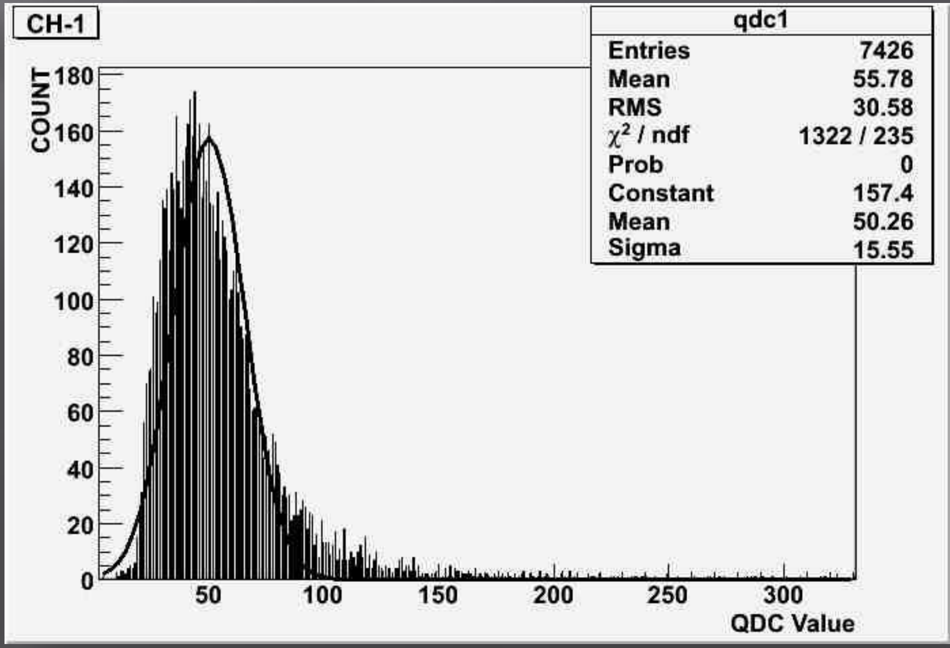
Mean pulse height from the RPC: 2.5-3mV

Charge and time distributions

Charge

Timing

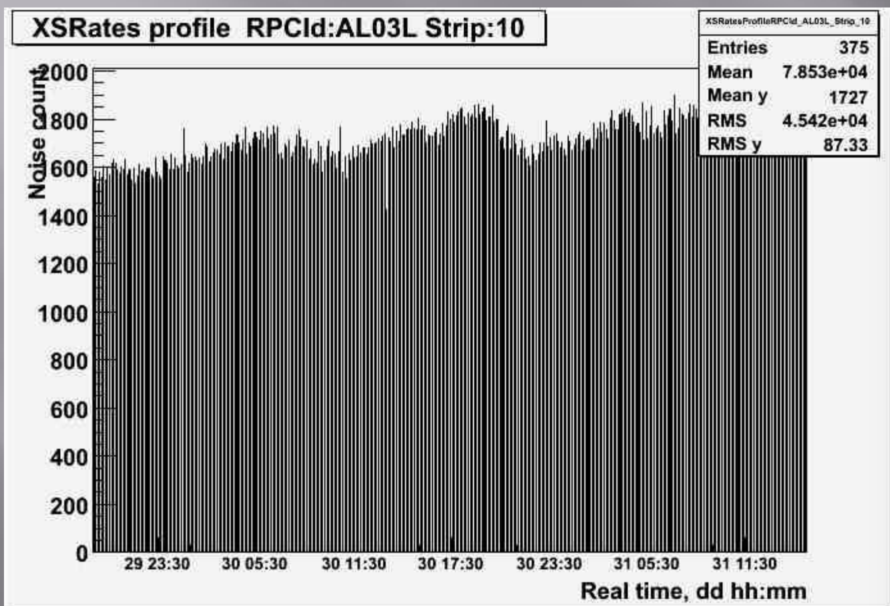


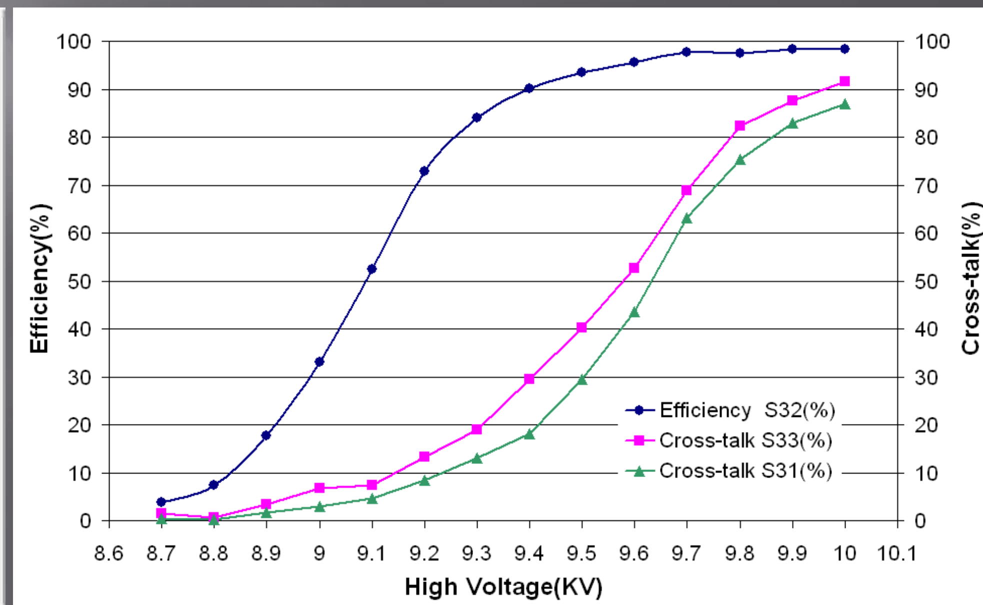


Monitoring operating parameters

Efficiency plateau

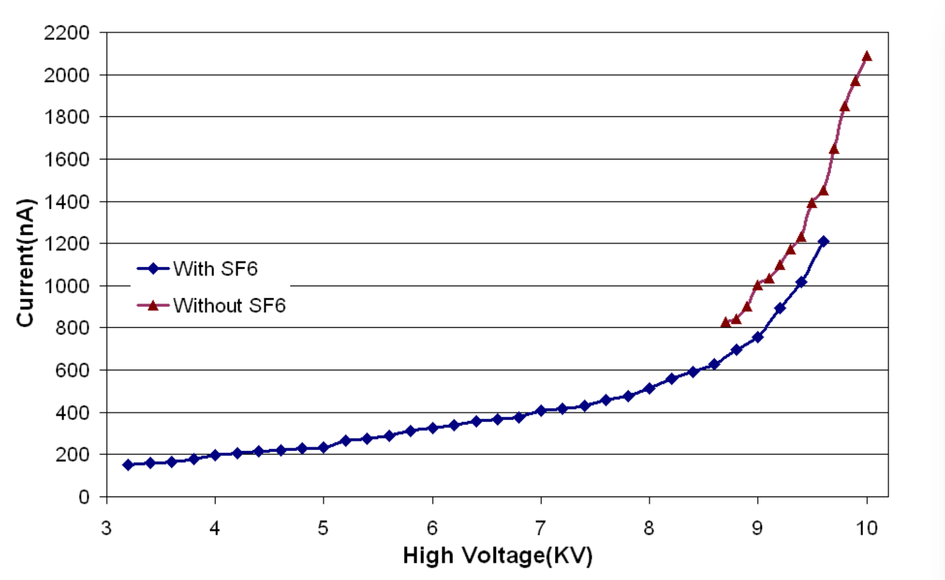
Noise rate profile



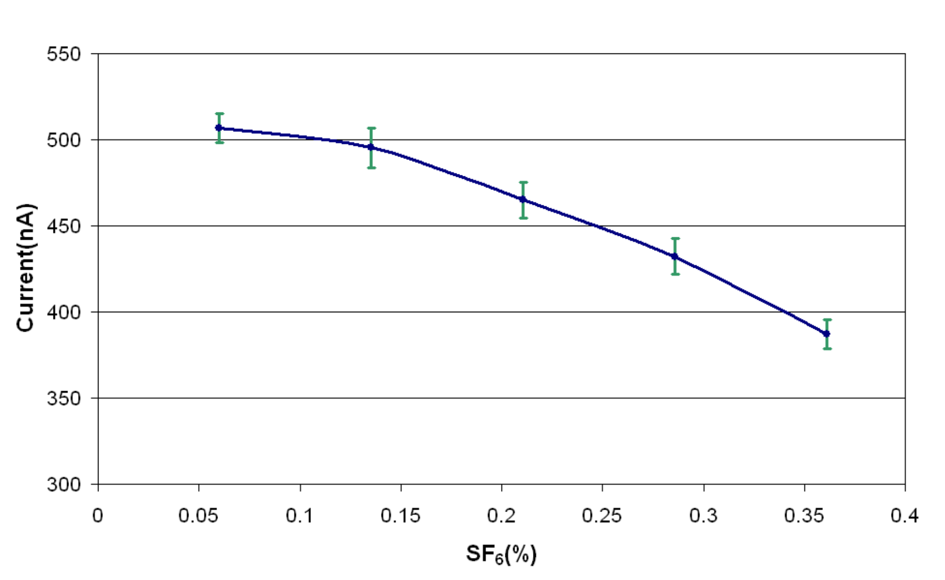


SF_6 studies: Chamber current

V-I characteristics

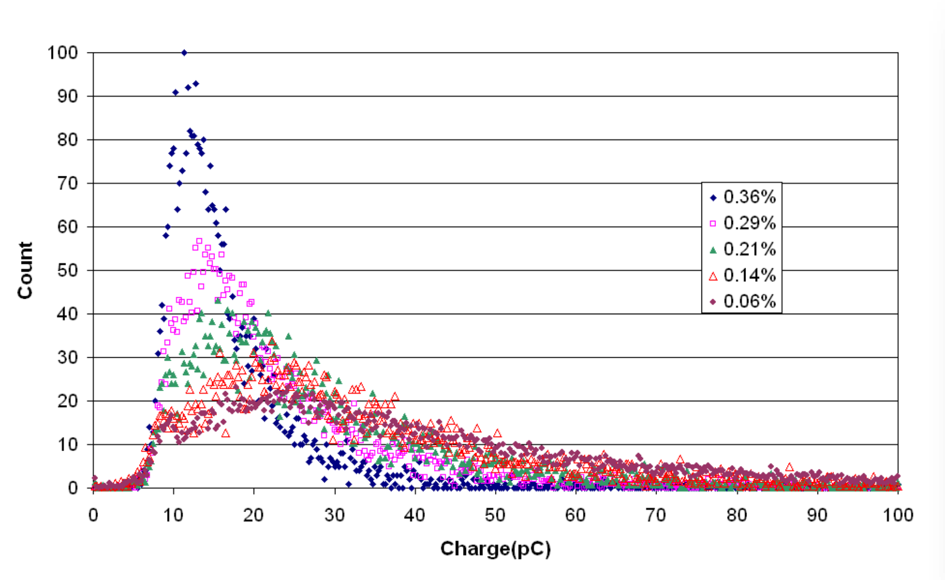


Chamber current

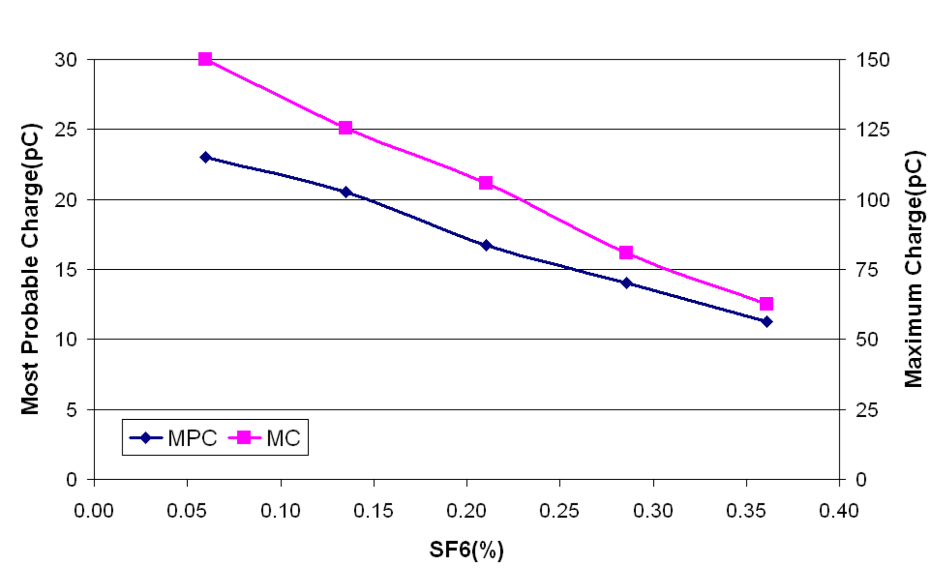


SF_6 studies: Collected signal charge

Charge distributions



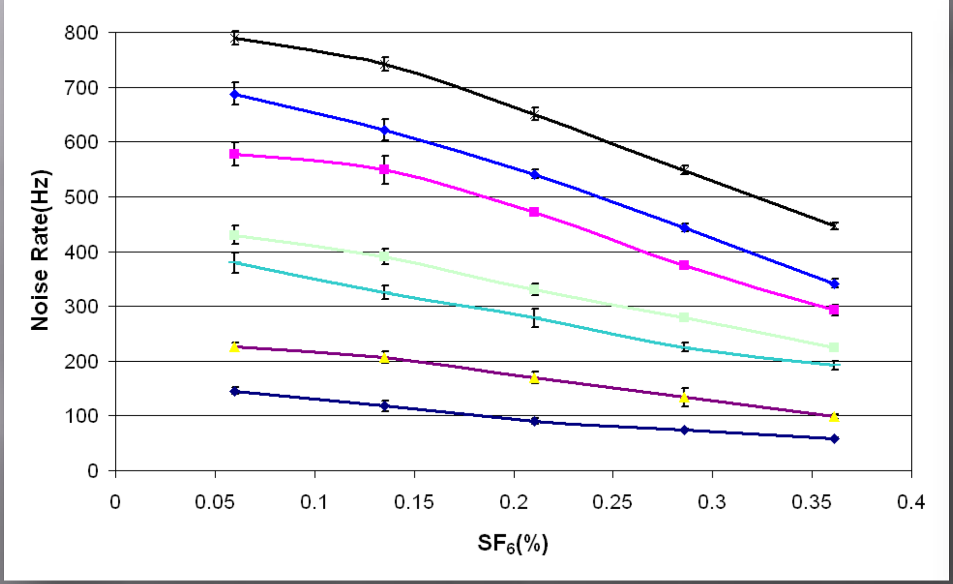
Charge parameters

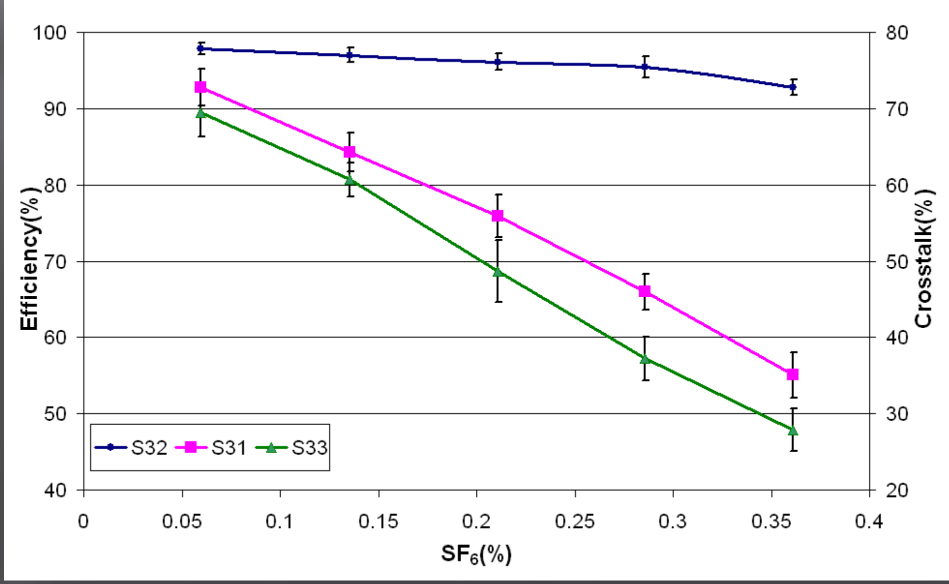


SF_6 studies: Important operating parameters

Efficiency

Noise Rate

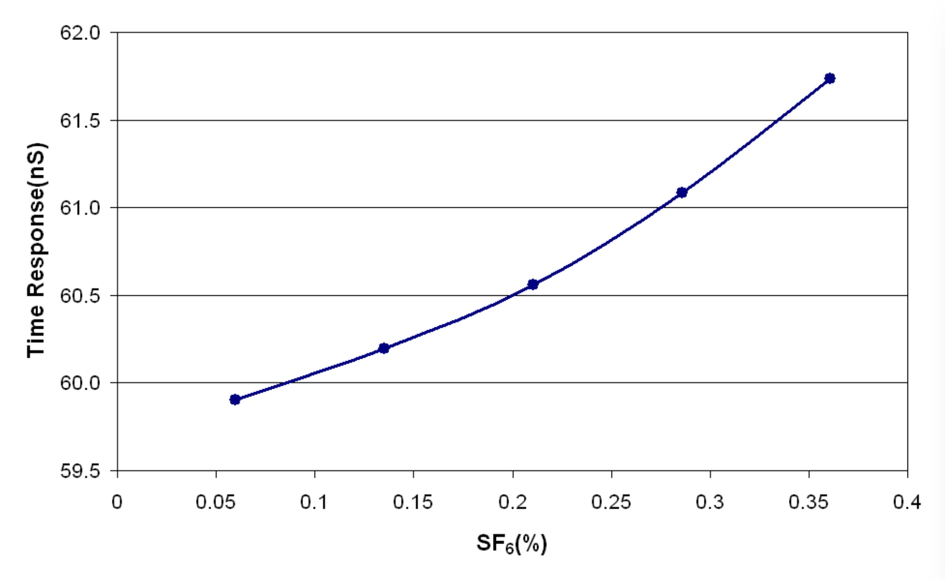


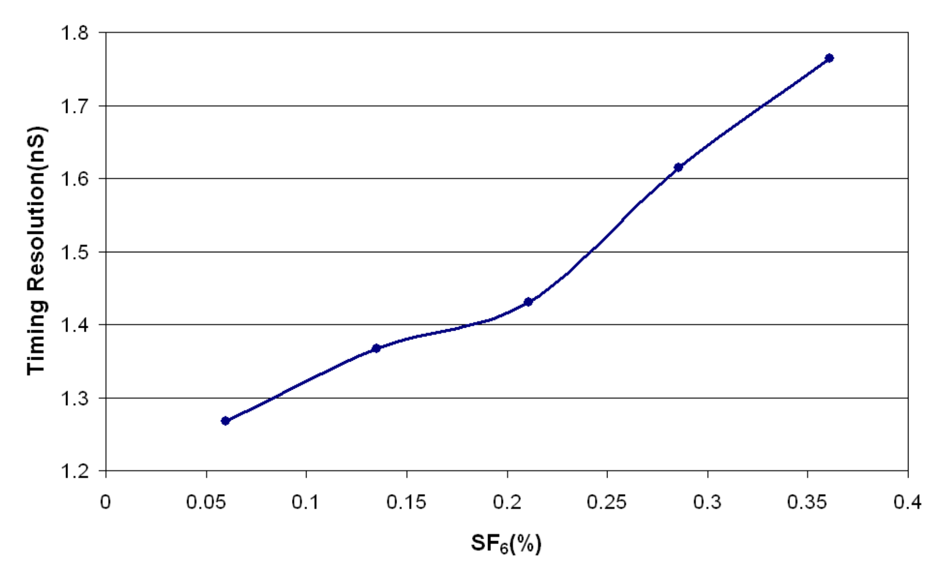


SF_6 studies: Timing characteristics

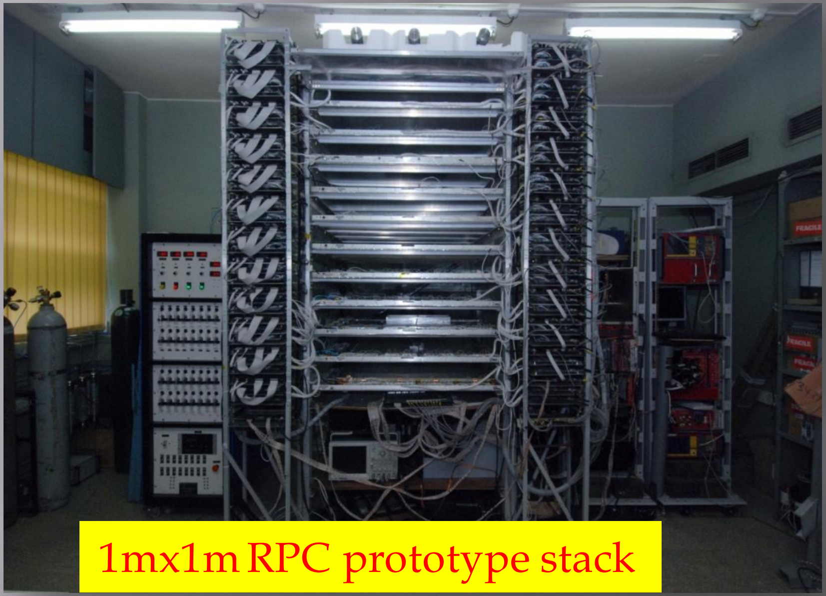
Time response

Time resolution



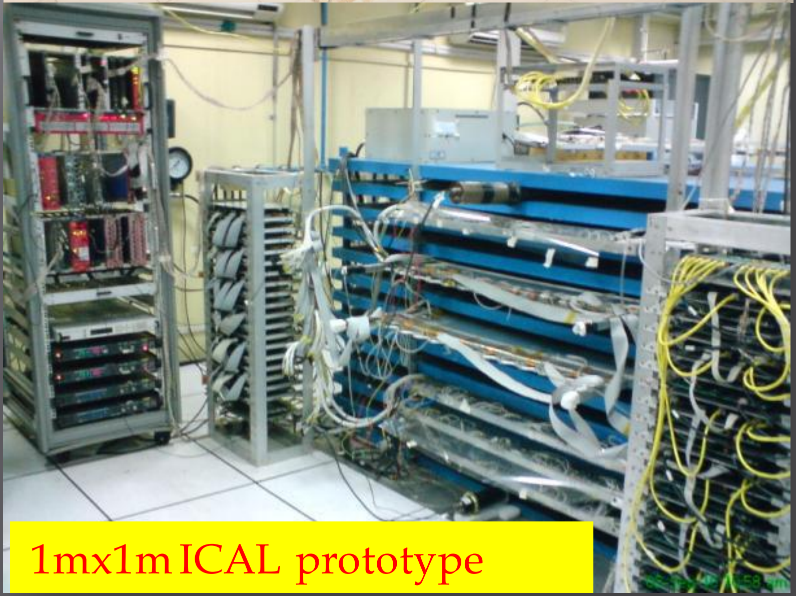


Prototyping of ICAL detector

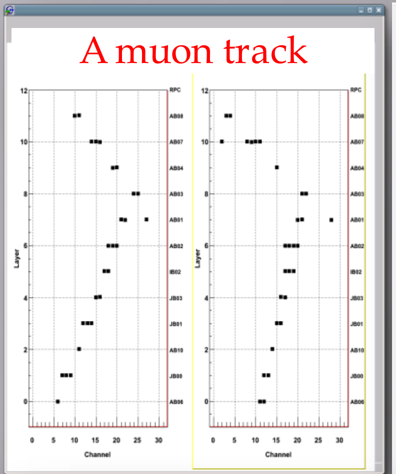

1mx1m RPC prototype stack

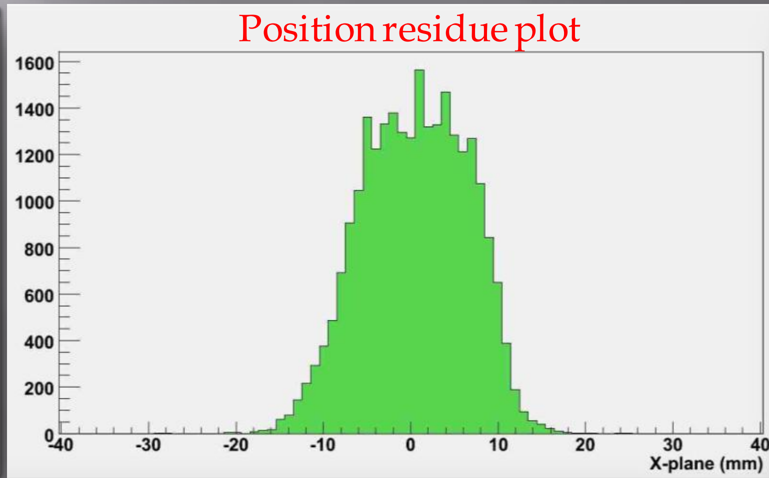

2mx2m RPC test stand

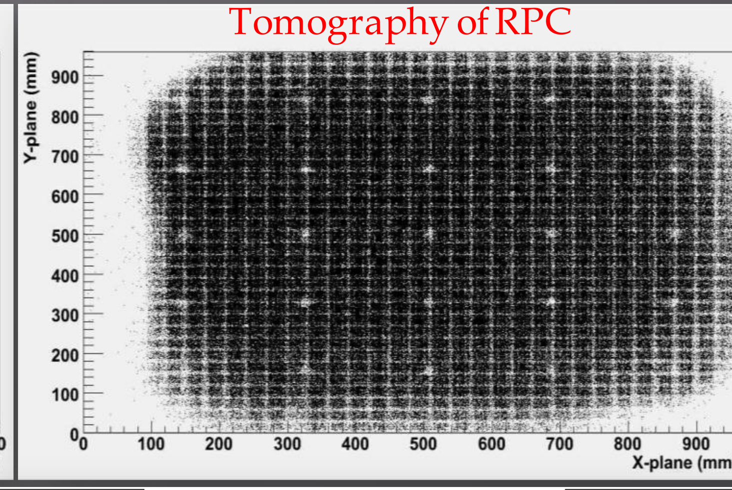

Industrial production of RPC

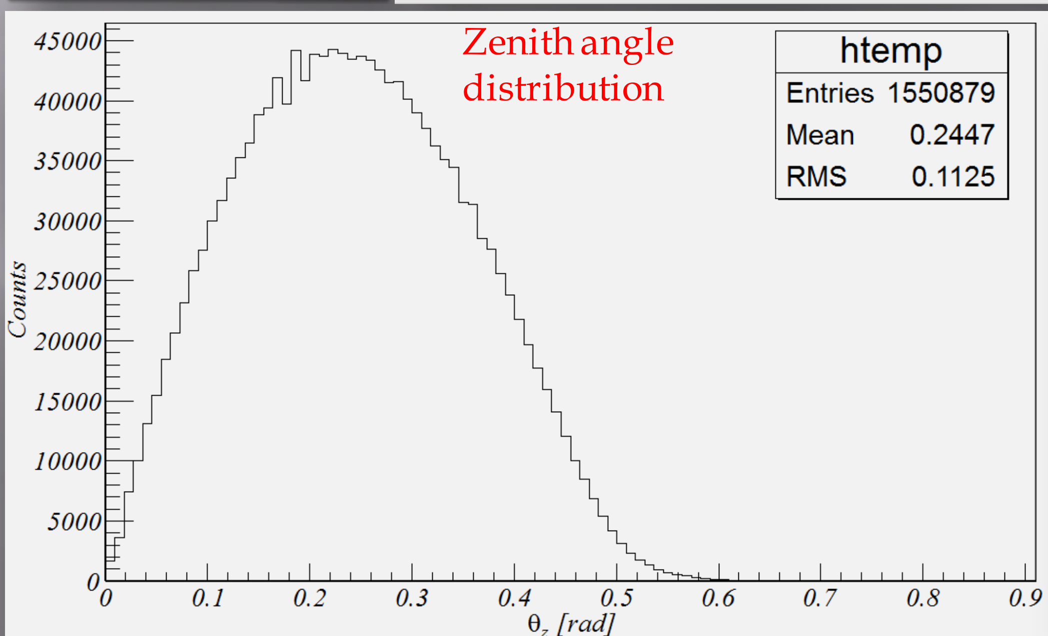

1mx1m ICAL prototype

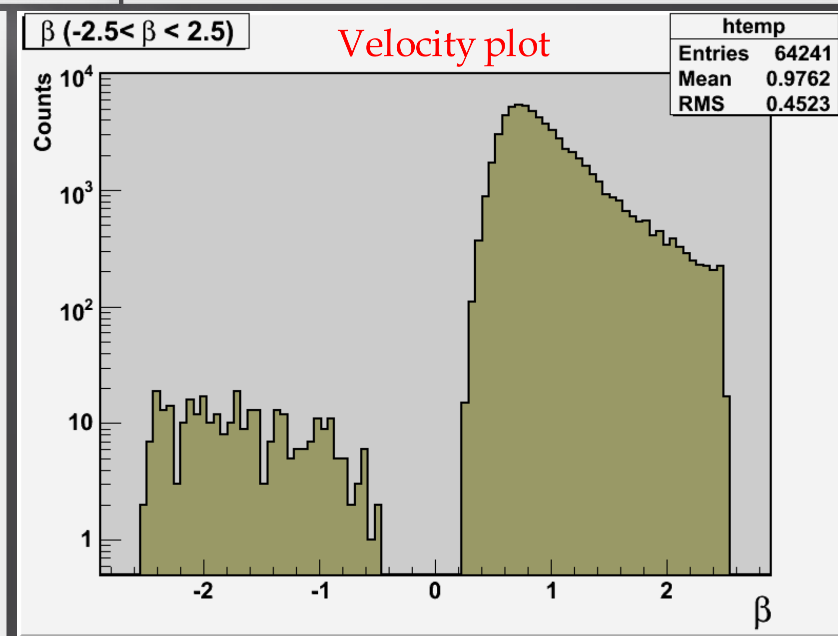
Results from prototype stack



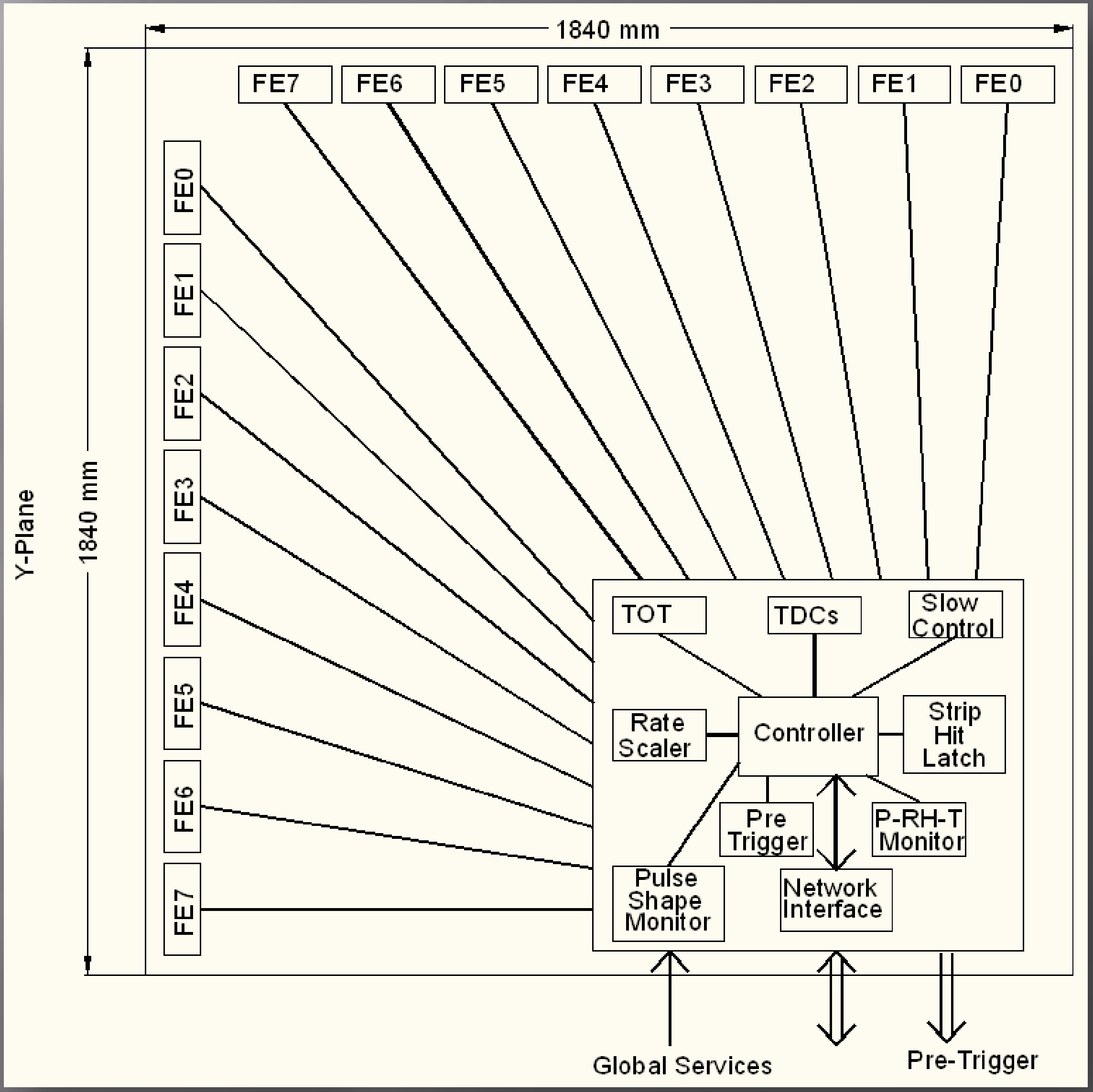






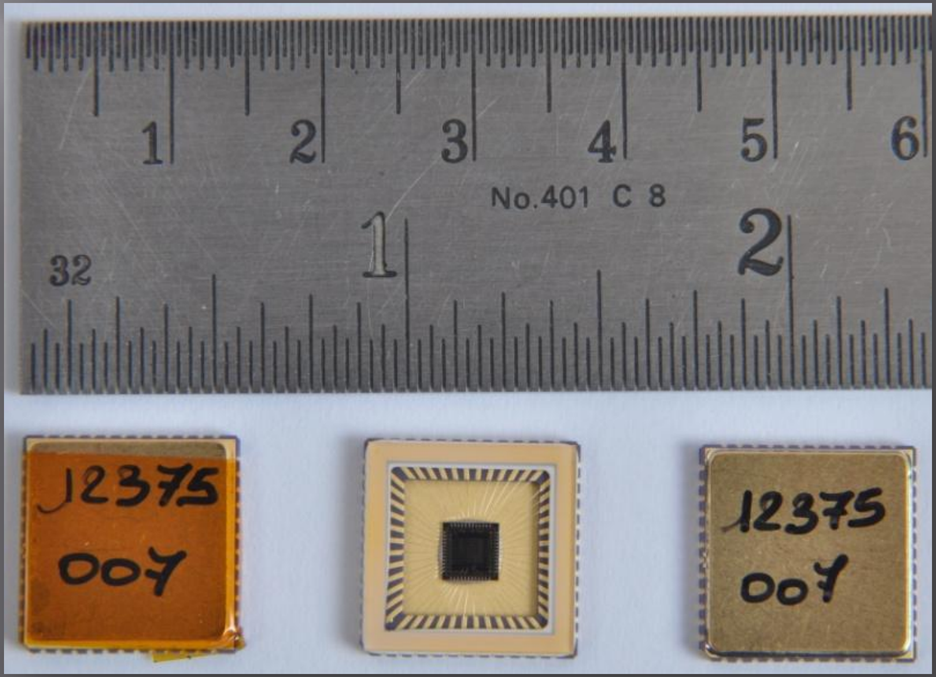


Functional diagram of RPC-DAQ



Features of ICAL FE ASIC

- IC Service: Europractice (MPW), Belgium
- Service agent: IMEC, Belgium
- Foundry: austriamicrosystems
- Process: AMSc35b4c3 (0.35µm CMOS)
- Input dynamic range:18fC – 1.36pC
- Input impedance: 45Ω @350MHz
- Amplifier gain: 8mV/µA
- 3-dB Bandwidth: 274MHz
- Rise time: 1.2ns
- Comparator's sensitivity: 2mV
- LVDS drive: 4mA
- Power per channel: < 20mW
- Package: CLCC48(48-pin)
- Chip area: $13mm^2$



Power supplies

- High voltage for RPCs
  - Voltage: 10kV (nominal for Glass, less for Bakelite)
  - Current: 6mA (approx., 200nA per chamber)
  - Ramp up/down, on/off, monitoring
- Low voltage for electronics
  - Voltages and current budgets still not available
- Commercial and/or semi-commercial solutions
  - Buy supplies, design distribution(and control)?
- DC-DC and DC-HVDC converters; cost considerations

Cables and interconnects

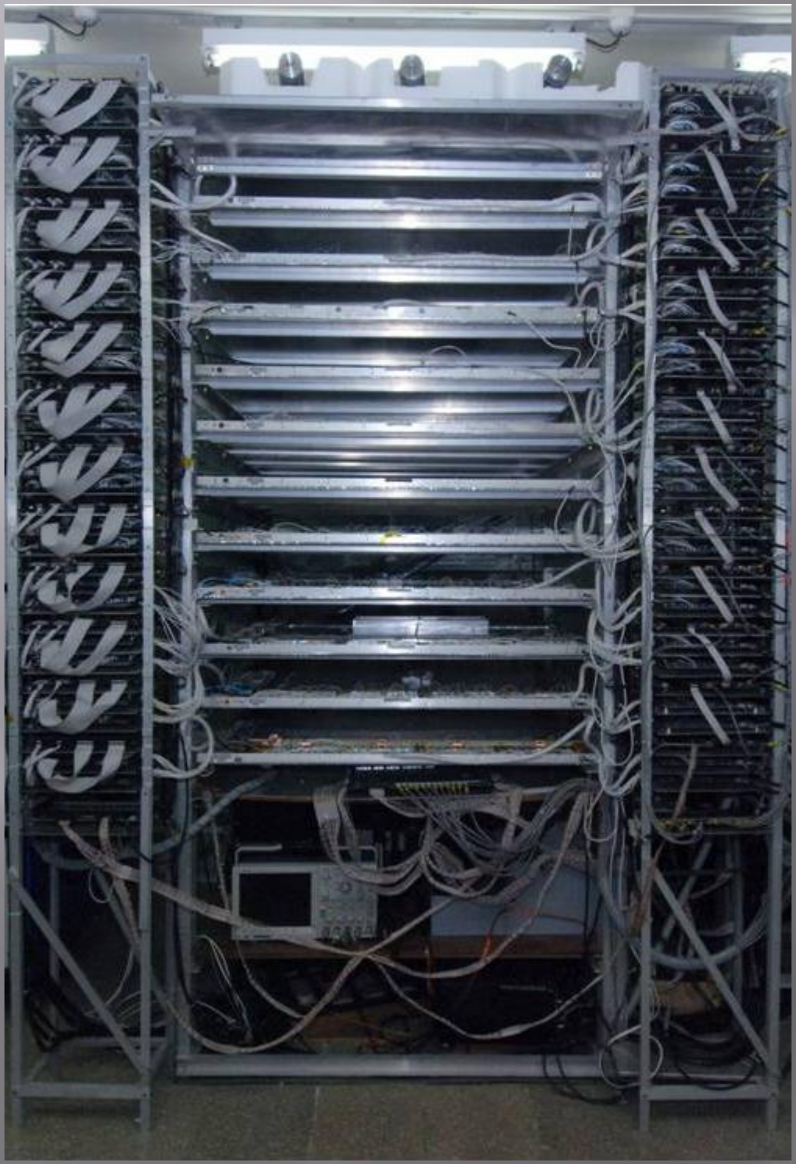
- RPC to front-end boards – *the toughest!*
  - Integration with pickup panel fabrication
- Front-end boards to RPC-DAQ board
  - LVDS signals (any alternatives?, prefer differential)
  - Channel address
  - Analog pulse
  - Power
- RPC-DAQ boards to trigger sub-systems
  - Four pairs, Copper, multi-line, flat cable?
- RPC-DAQ boards to back-end
  - Master trigger
  - Central clock
  - Data cable (Ethernet: copper/fibre, …)

Requirement of gases in ICAL

Total number of RPCs in ICAL = 3 × 150 × 64 = 28,800
Total gas volume = 28,800 × 184cm × 184cm × 0.2cm = 195,010 litres
For example:
One volume change/day with 10% gas top-up in a re-circulating scheme
Approximate running gas cost = Rs 30,000/day (R134a from Mafron)

Gas	Avalanche (%)	Streamer (%)	Maximum (%)	Volume (L)	Density (g/L)	Weight (Kg)	Cost (Rs/Kg)
Argon	0.0	30.0	30.0	58,503	1.784	104.4	
R134a	95.5	62.0	95.5	186,234.6	4.25	791.5	
Isobutane	4.3	8.0	8.0	15,600.8	2.51	39.16	
SF_6	0.2	0.0	0.2	390	6.164	2.40	

Sealed gas test for *C217* stack

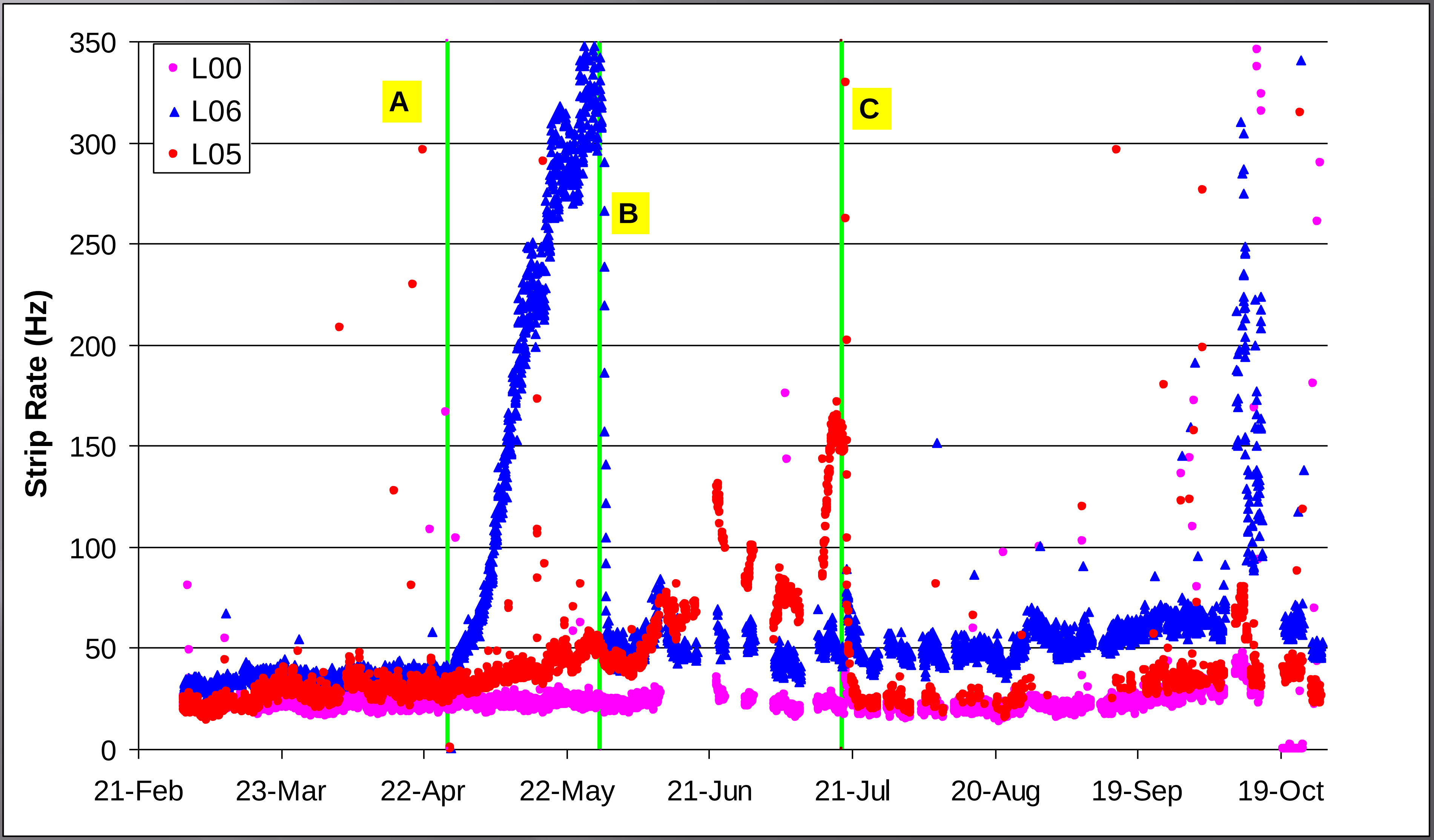


- Stack of 12 1m×1m RPCs
- L0, L4 and L11 were used as reference
- Other RPCs sealed on April 27, 2010

Summary of the study

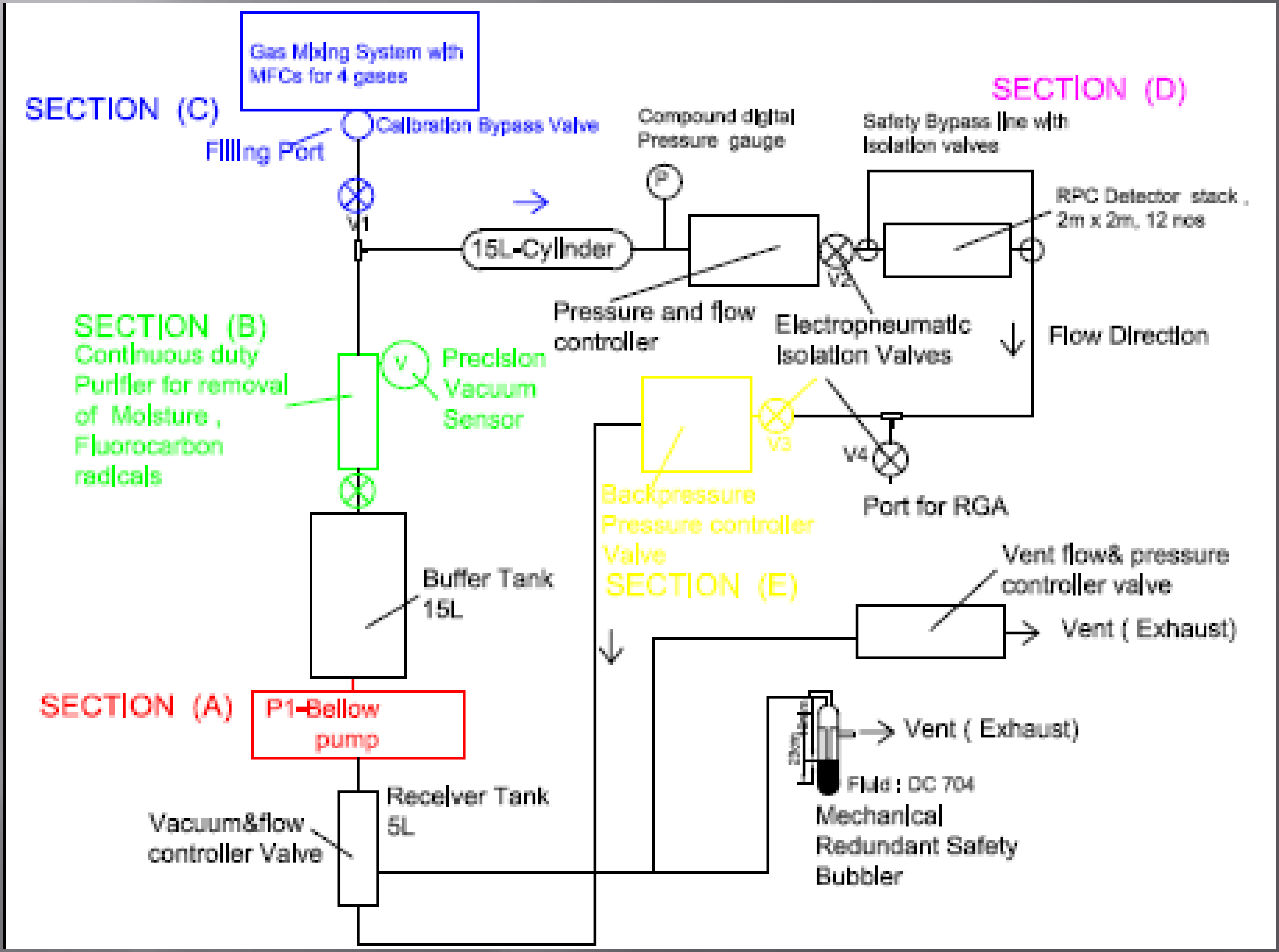
Sl. no	Layer No	RPC Name	Sealing date	Gas flow restarted	No of days sealed
1	L00	AB06	--------------	--------------	--
2	L01	AB07	27-Apr-10	19-Jul-10	83
3	L02	AB10	27-Apr-10	19-Jul-10	83
4	L03	AB11	27-Apr-10	31-May-10	34
5	L04	AB09	--------------	--------------	--
6	L05	IB02	27-Apr-10	19-Jul-10	83
7	L06	AB02	27-Apr-10	29-May-10	32
8	L07	AB01	27-Apr-10	29-May-10	32
9	L08	AB03	27-Apr-10	19-Jul-10	83
10	L09	AB04	27-Apr-10	29-May-10	32
11	L10	AB12	27-Apr-10	28-May-10	31
12	L11	AB08	--------------	--------------	--

Comparison of leaky RPCs



A = Sealed (L05, L06) **B = Flow started (L06)** **C = Flow started (L05)**

Closed loop recirculation system



Outlook

- Issues on RPC gap production
  - Size, glass coating technique, high voltage contact
- Pickup panel optimisation
  - Cost, thickness, fire safety issue
- RPC unit integration issues
  - Electronics, gas, cooling, support structure
- Industrial procedure optimisation
  - Spacer & button gluing, curing, QC scheme
- Large scale industrial production
  - Many local industries are interested and getting involved
- Gas system/flow optimisation
  - Recycling system, flow control, optimisation, monitoring