RPC DHCAL R&D in IHEP - Protvino

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Outline

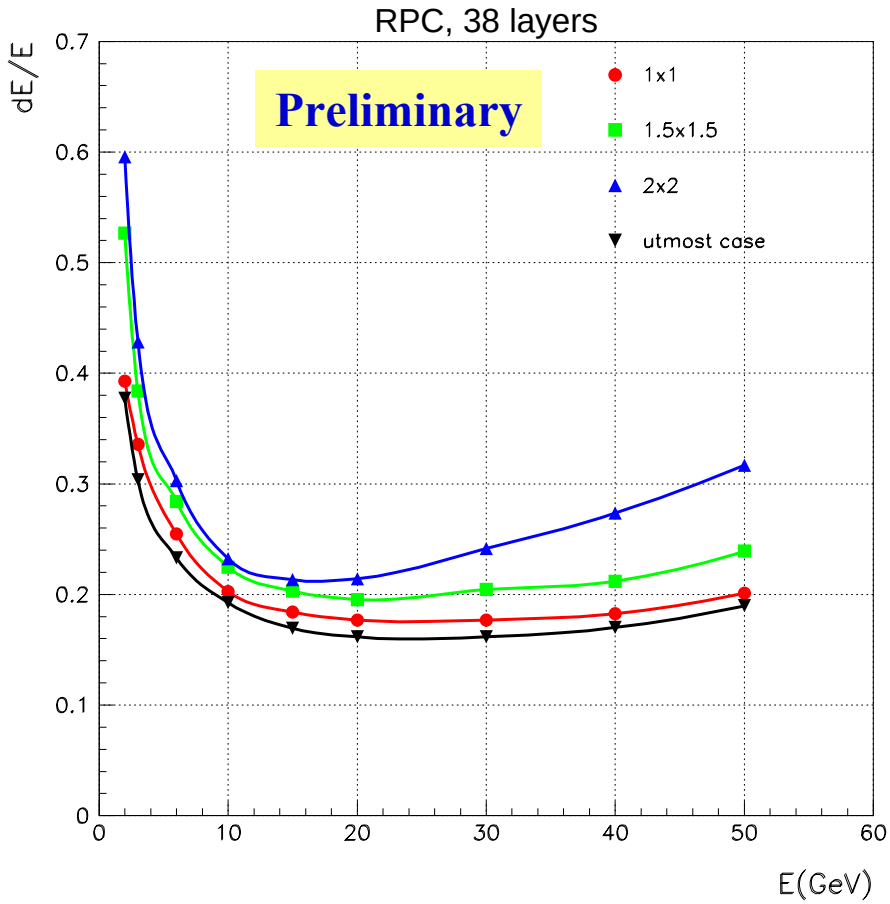
1. Selection of DHCAL RPC performance
2. Further R&D
   - 5T mag field test
   -mini DHCAL prototype
   -1 m3 DHCAL prototype
3. Summary

DHCAL RPC performance

RPC pad size

GEANT 3.2 simulation
of DHCAL response for pions

- 38 layers – 2cm SS absorber,
  6.5 mm RPC
- RPC – 1.2 mm gas monogap,
  TFE gas, glass as resistive plates
- MIP/2 cut
- nonlinearity is taken into account



1x1 cm2 pads case is compatible when all hits are counted

R_M ~ 1.65 cm

DHCAL RPC performance

Gas mixtures

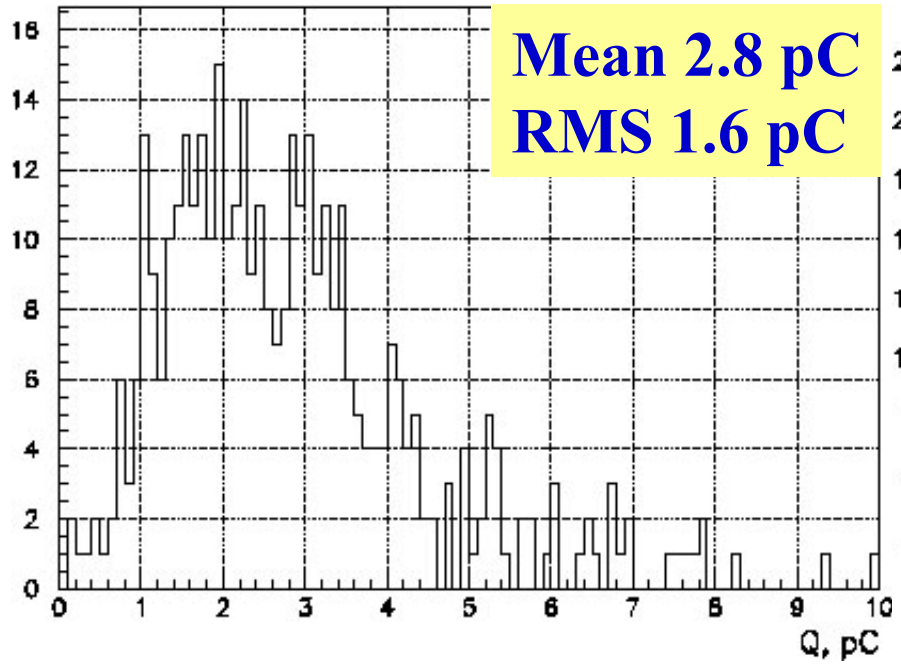
RPCs were tested in saturated avalanche and streamer modes
For both modes
TetraFluoroEthane (TFE) based mixtures were used
TFE = freon 134A = $C_2H_2F_4$
~ 8 ionizations/mm

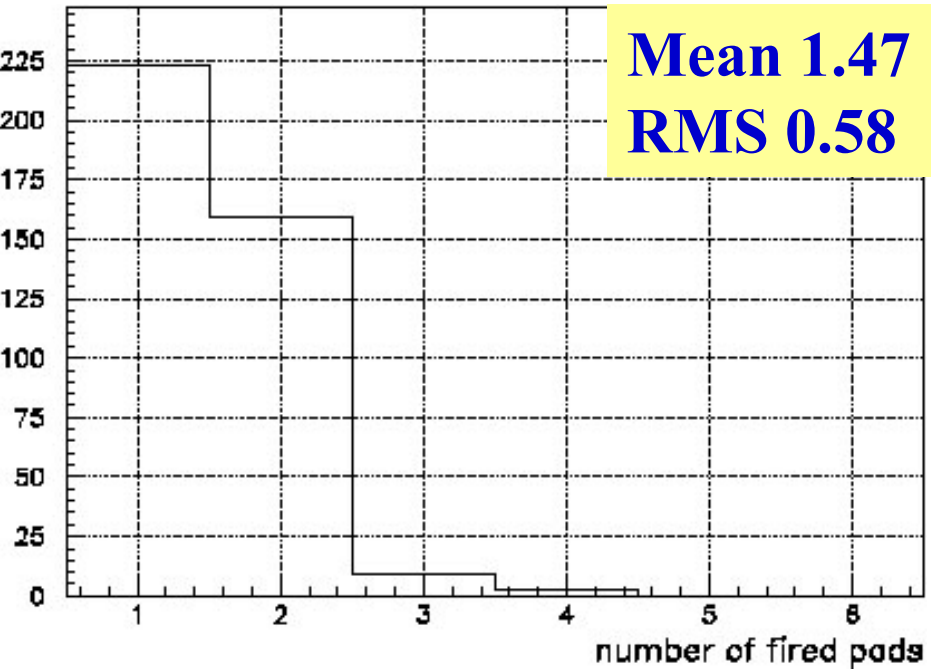
Saturated avalanche mixtures = TFE/IB/SF_6
IB = Iso-C_4H_{10} as quencher, IB fraction = 5%
SF_6 as streamer suppresor, SF_6 fractions = (2-5)%

Streamer mixtures = TFE/IB/Ar or N_2
IB = Iso-C_4H_{10} as quencher, IB fraction= (5-20)%
Ar/N_2 as streamer developer, fractions = (2-20)%

RPC in avalanche mode

Typical Q and m distributions
1.2 mm, 2% SF_6, 8.4 kV - working point, 2.2 mV thr





Q ~ 10^7 e

2 adj pads

RPC in avalanche mode

1.2 mm gap RPC

eff, <m> vs HV

- 2% and 5% of SF_6

Thresholds O - 0.6 mV

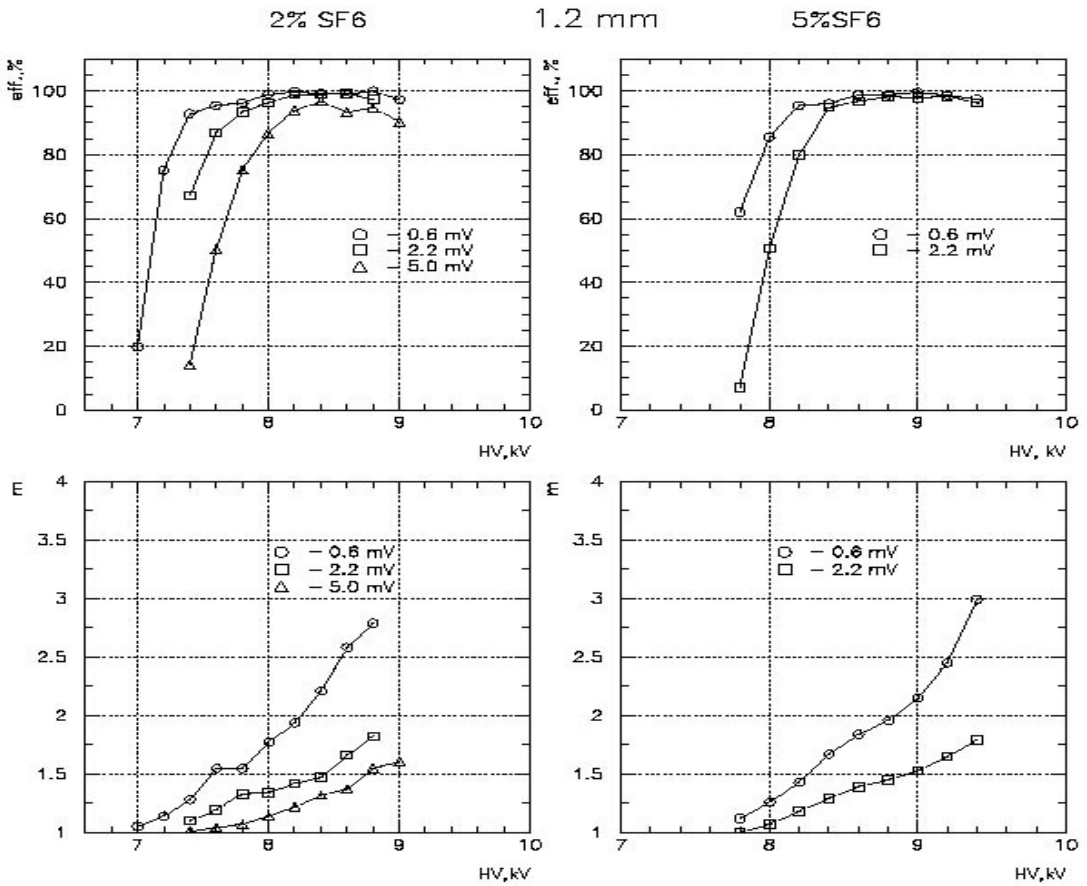
□ - 2.2 mV

Δ - 5.0 mV

2.2 mV is best threshold

eff >99%

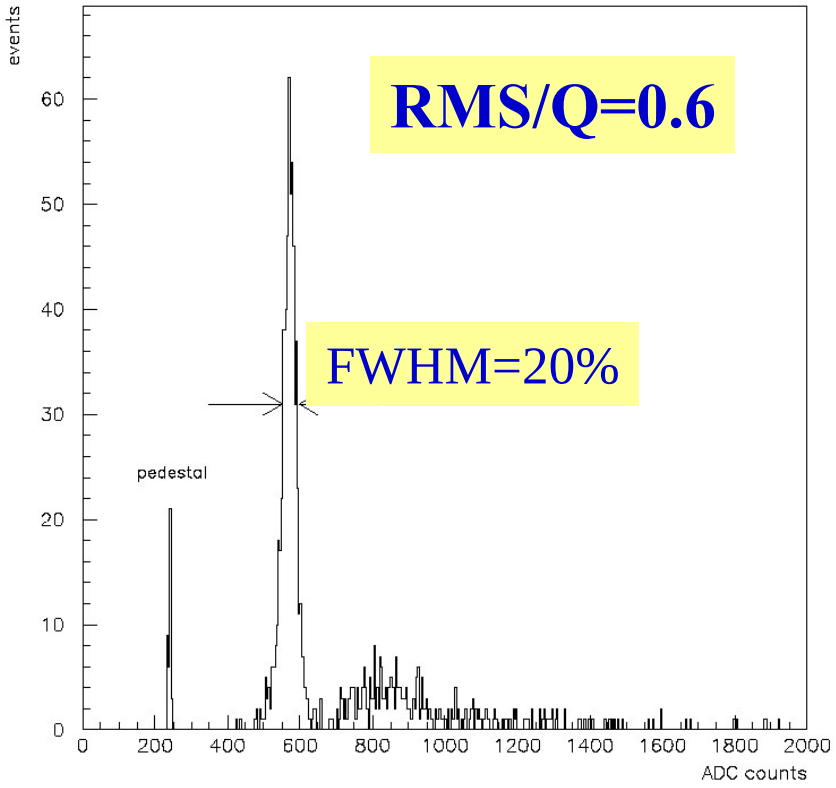
low <m> ~ 1.4

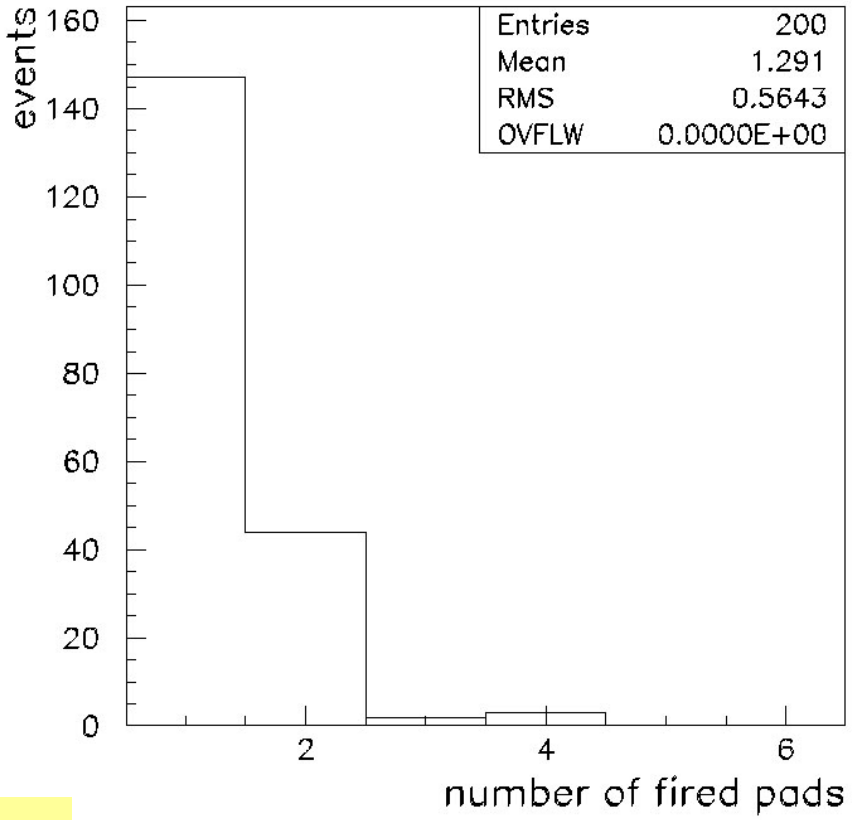


For 2.2 mV	**Knee**	**8.2 kV**	**8.6 kV**
	ΔV	**0.6 kV**	**0.6 kV**

RPC in streamer mode

Typical Q and M distributions, 200 V above knee
1.2 mm gap, TFE/Ar/IB=80/10/10



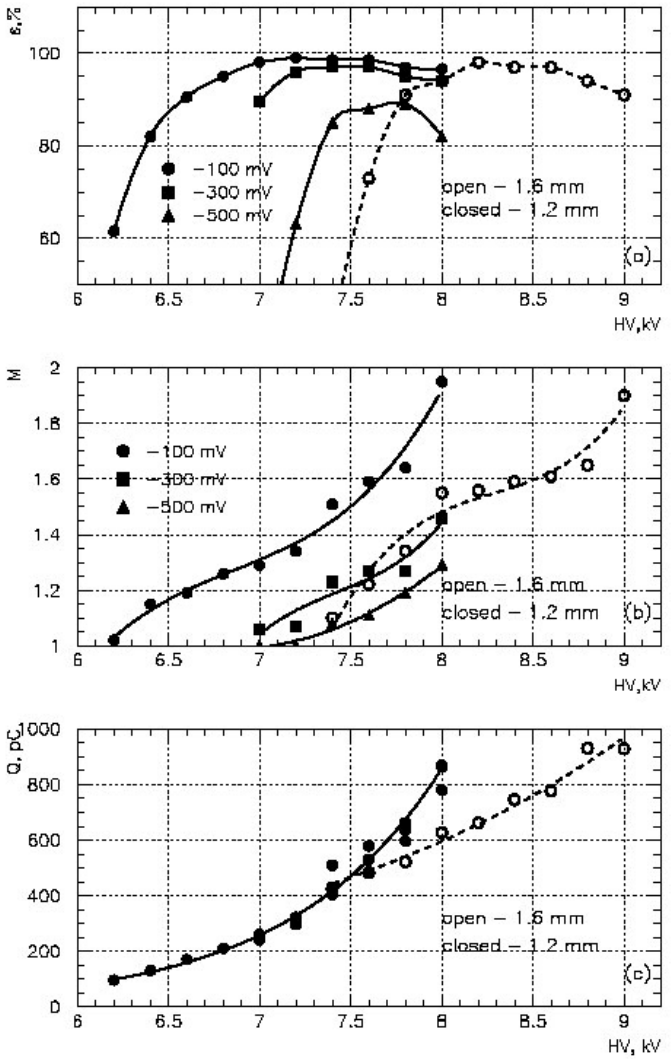


No ways to suppress multi streamer tail

RPC in streamer mode

Eff, M and Q vs HV
for 1.2 and 1.6 mm gaps
Ar10 mix
for different thresholds

best choice - thr = 300 mV



Comparison of avalanche and streamer modes

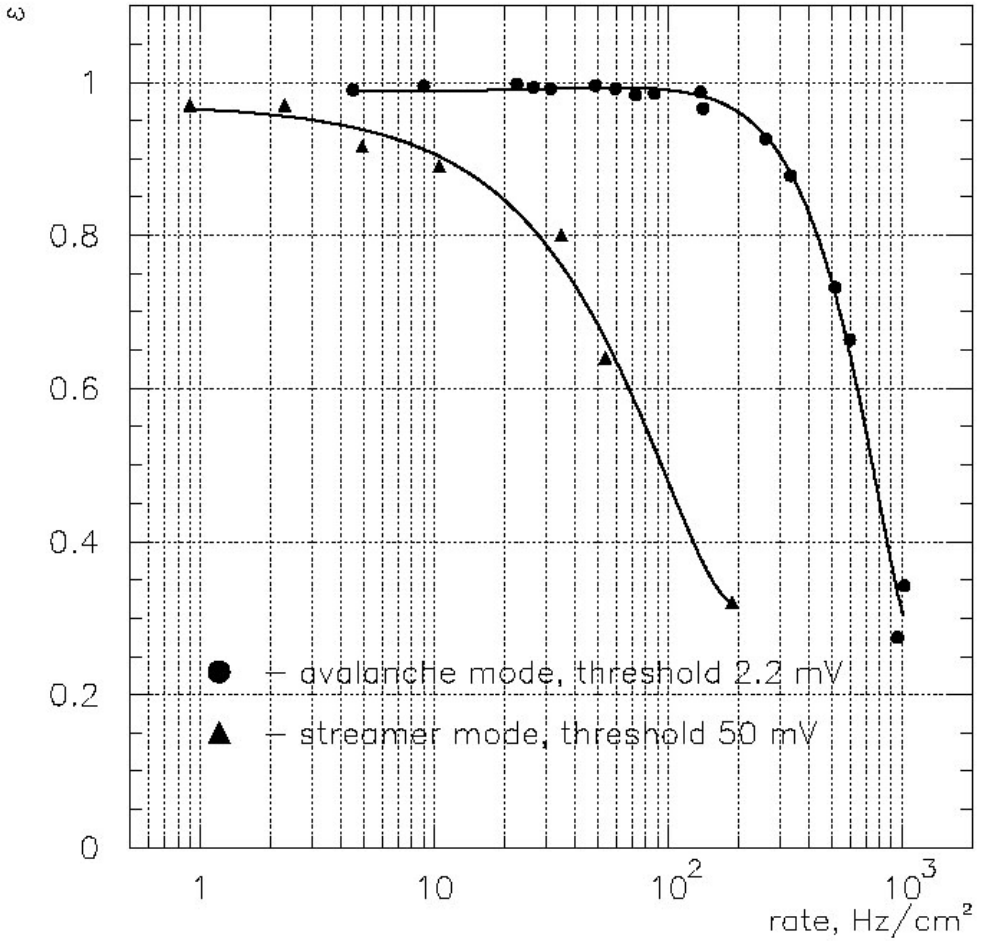
Rate capability

streamer ~2-3 Hz/cm²

avalanche ~100 Hz/cm²

It is hard to work in streamer mode even for usual beam conditions

Streamer is suitable only for very low rates like e+e⁻ FLC



Comparison of avalanche and streamer modes

As example, for 1.2 mm gap

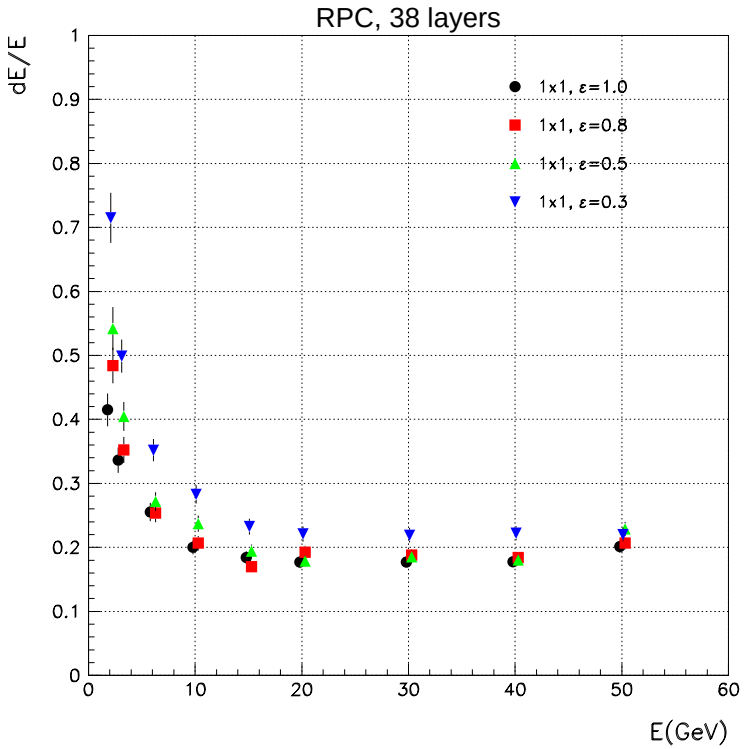
№	Item	avalanche	streamer
1	Working mixture	TFE/Iso/SF6=93/5/2	TFE/Iso/Ar=80/10/10
2	HV working point, kV	7.4	7.4
3	Induced charge, pC	3.4	400
4	Threshold on 50Ω, mV	1-2	300
5	Efficiency, %	~98	~95
6	σ_Q / Q	~ 0.9	~ 0.6
7	Pad multiplicity	1.4-1.5	1.2 - 1.3
8	Noise, Hz/cm^2	~ 0.7	~ 0.1
9	Rate capability, Hz/cm^2	100	2 - 3

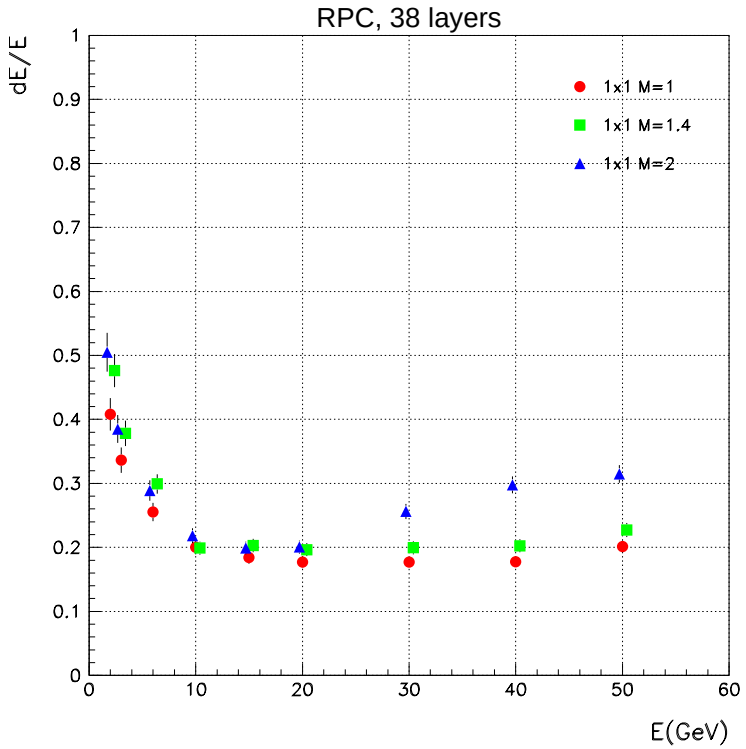
Summary of RPC features

№	Item	Value	Comments
1	Pad size	1x1 cm2	
2	Number of gaps	monogap	
3	Mode of operation	saturated avalanche	
4	Working mixture	TFE/Iso/SF6=93/5/2	
5	Gas gap	1.2 mm	1.6 mm can be used
6	Resistive plates	thin glass,10^13 Ω·cm	
7	HV working point, kV	7.4	
8	Induced charge, pC	~3	
9	Threshold on 50Ω, mV	1-2	
10	Efficiency, %	~98	
11	HV plateau	~600 V	
12	σ_Q / Q	~ 1	
13	Pad multiplicity	1.4-1.5 ?	
14	Noise, Hz/cm^2	~ 0.5	
15	Rate capability, Hz/cm^2	≤100	
16	Resistivity of HV coverage	> 10^6 Ω/ sq	
17	Control of RPC work	Q RO of cathode strips	
18	Maximal own RPC thickness	6 mm	try to keep 5 mm
	with 2 mm SS cups	10 + 0.5 mm	

DHCAL RPC performance

Geant3 simulations





It seems eff down to 80%
does not hurt resolution much

It seems <m> up to 1.4-1.5
does not hurt resolution much

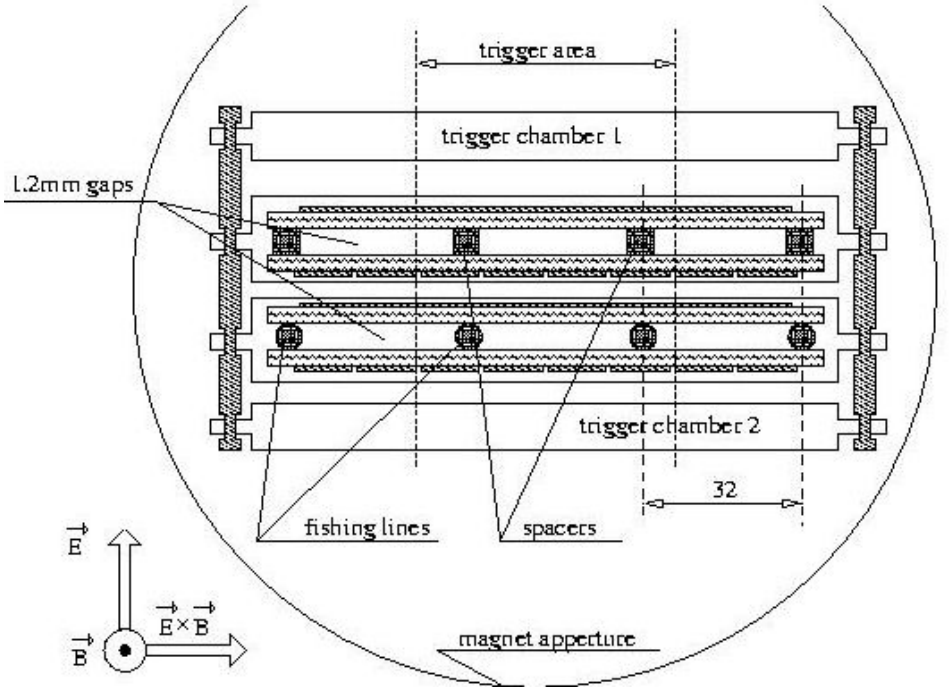
Further R&D

Assembly for 5T test

It was proposed to test RPCs in 5T magnetic field at DESY to check influence of electron spiralization

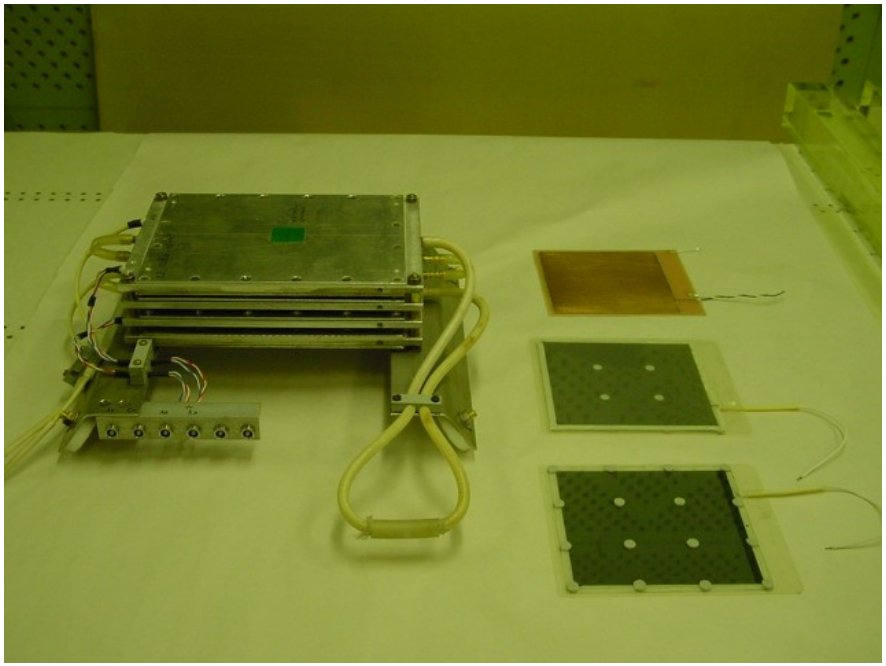
Here is our proposal for this test with 64 pad RPCs

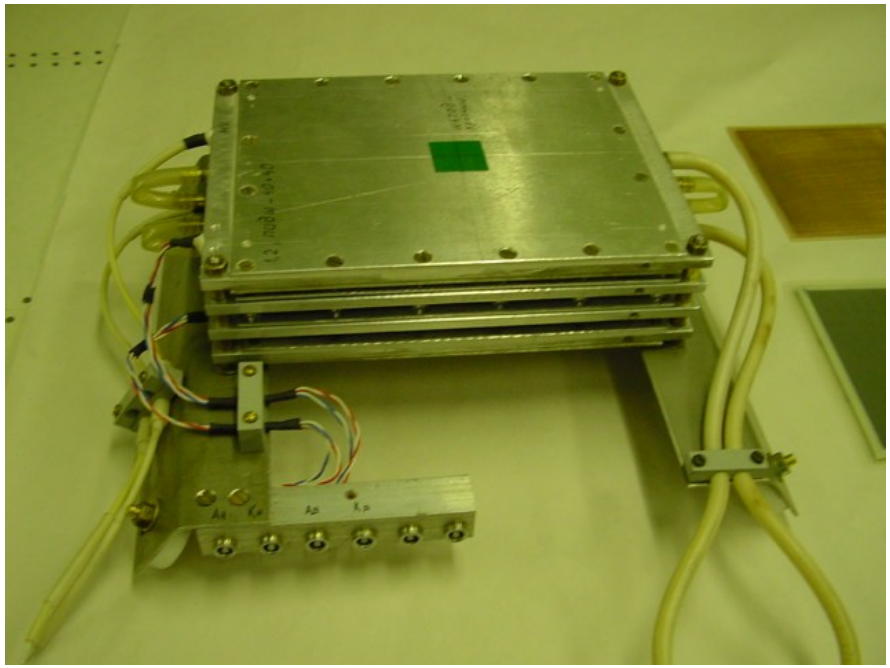
Expected in May-June 04



Further R&D

5T test





Here is assembly which we would like to use

Further R&D

5T test

64 channel RO electronics

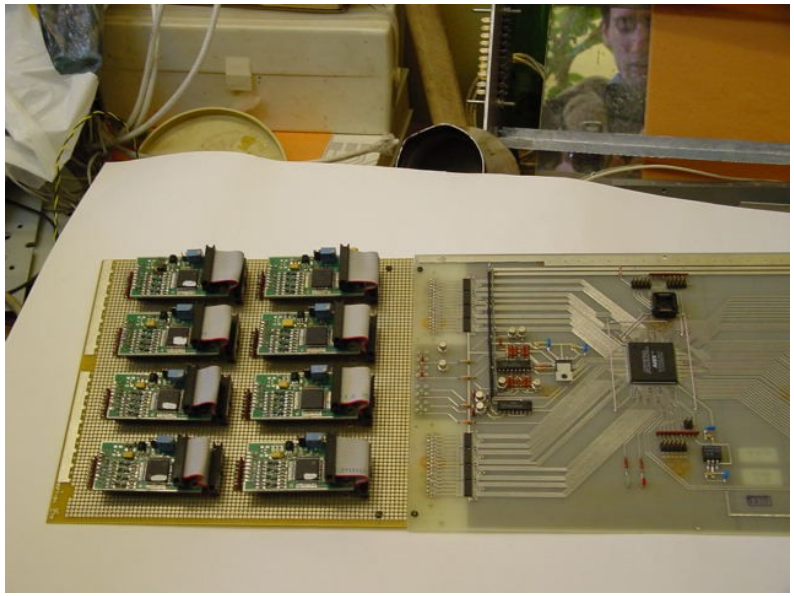
Analog part - Minsk old 8 ch. ASIC ANODE.
New one is delayed up to May

Digital part – ALTERA FPGA

Sequental read-out to PC

Was tested with RPC satisfactory

Final PCB is under development



Mini DHCAL prototype

To measure response for electrons with 10/20 layers

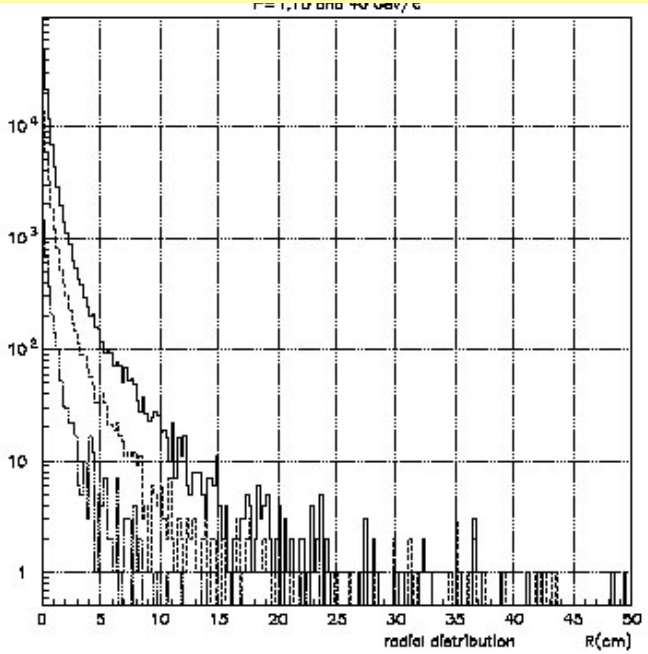
sampling: 4/2 cm steel + 0.65 cm RPC plane

sensitive area 9x9 cm^2 (8x8 pads of 1x1 cm^2, 1 mm spacing)

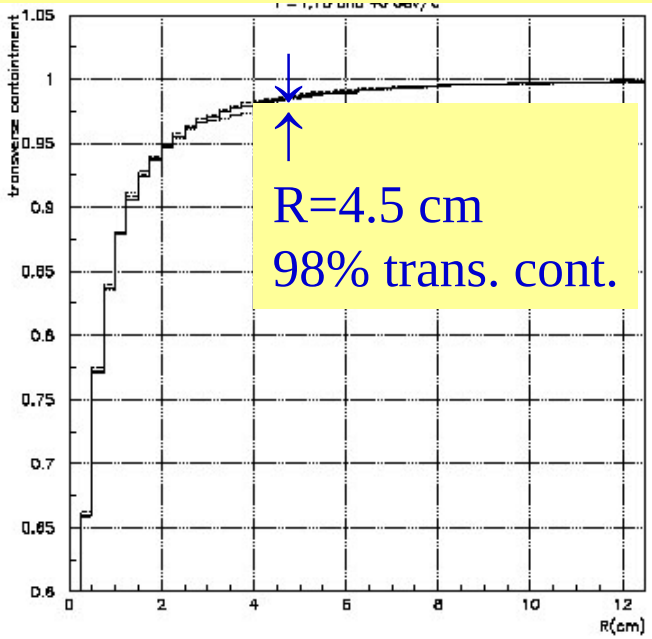
GEANT3 simulation of transverse containment

p_e=1,10,40 GeV/c

Diff. distr.



Trans. cont.

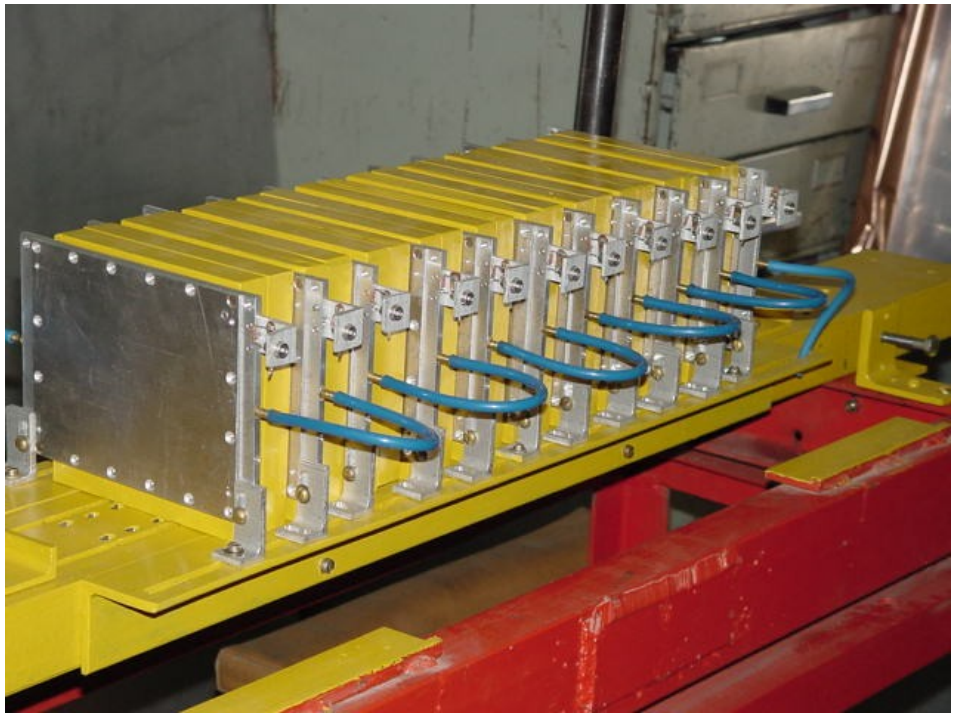


Mini DHCAL prototype

Goal – first digital measurements of electromagnetic showers and comparison with simulations.

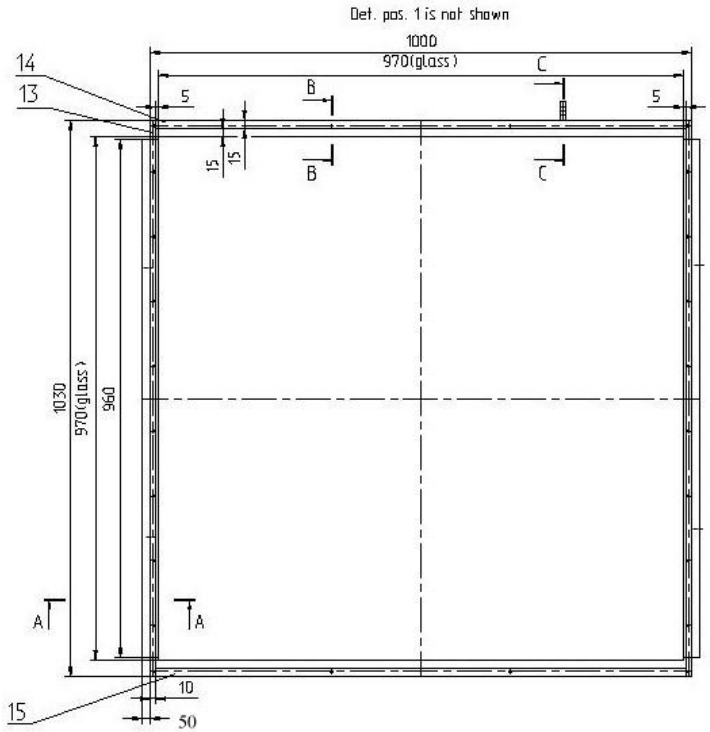
Usage of minimal number of RO channels ! (640/1280 ch.)

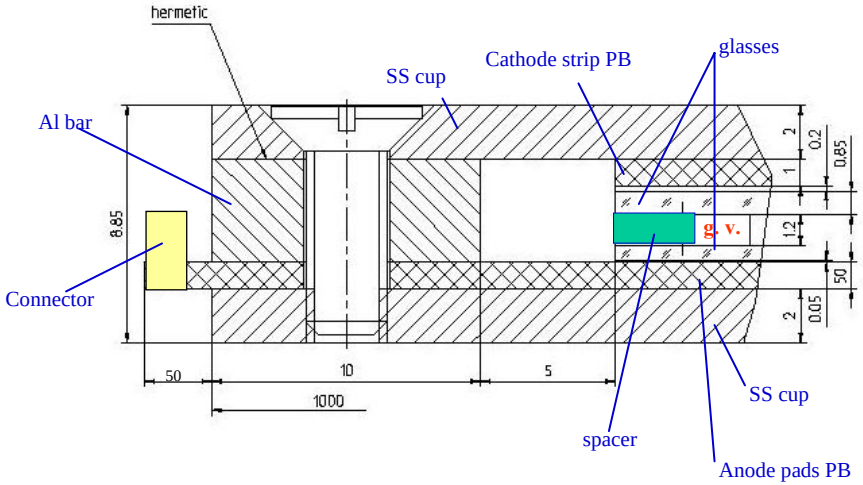
Most hard case for digital calorimetry !



1 m3 DHCAL prototype

Design of 1 m2 RPC plane





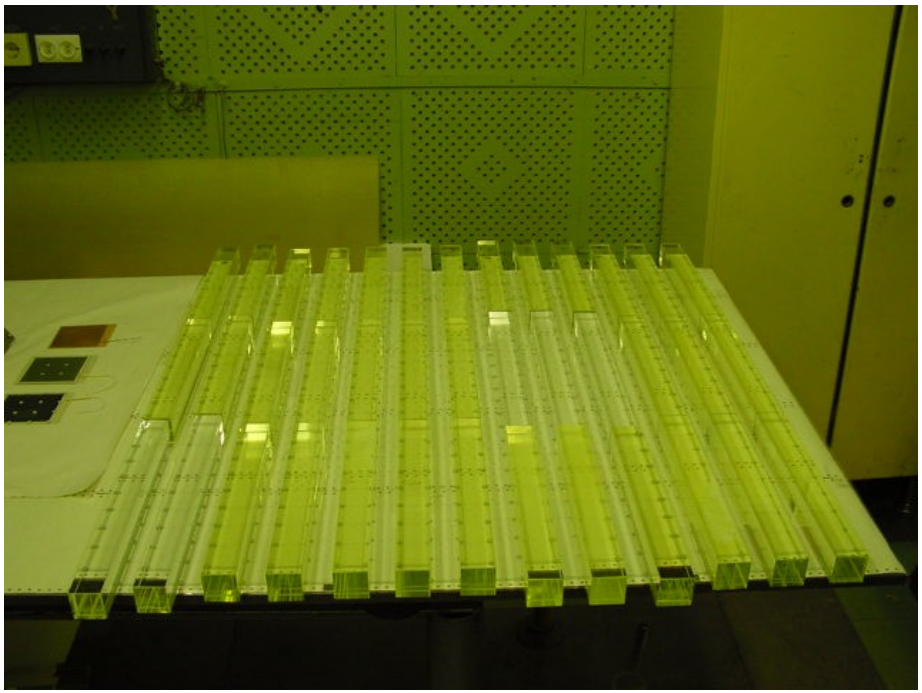
1000x1030 mm2 - lateral dimensions
970 x 970 mm2 – glass area
960 x 960 mm2 – sensitive area
Weight ~ 40 kg

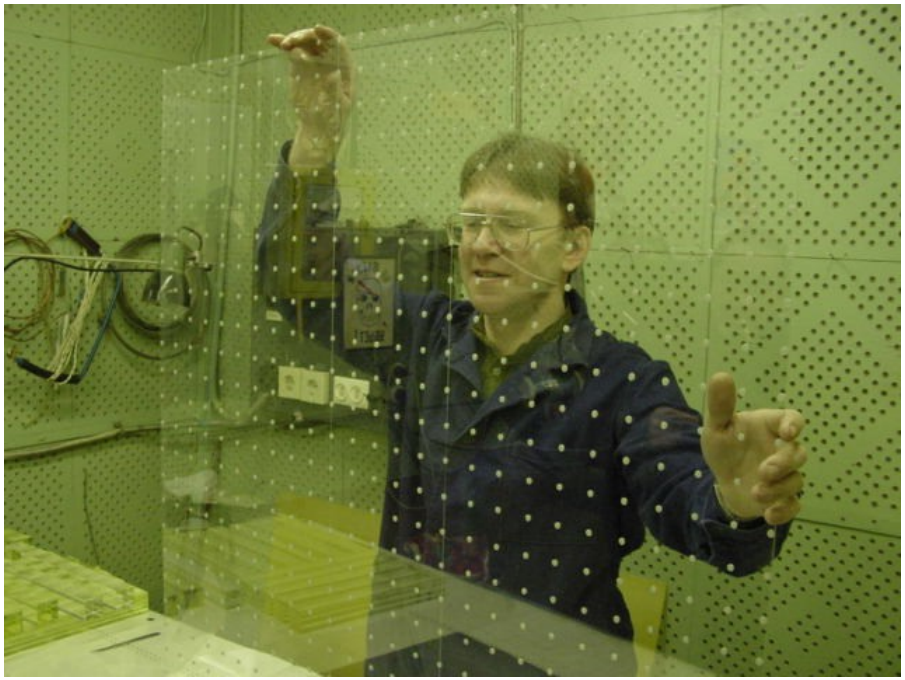
96x96 = 9216 anode pads in total
8 anode RPC PBs of 240x530 mm2
24x48 = 1152 pads on each

SS cups and Al bar frame form hermetic box.
It prevents glass break due to gas overpressure.

1 m3 DHCAL prototype

Construction of 1 m2 RPC plane





Gas volume: anode glass – 0.5 mm thick, cathode glass – 0.8 mm thick, 1.2 mm gas gap, 6 mm dia spacers

1 m3 DHCAL prototype

Construction of 1 m2 RPC plane

96x6 cm2 strips for read-out

16 anode (x) strips
16 cathode (y) strips

1 m3 DHCAL prototype

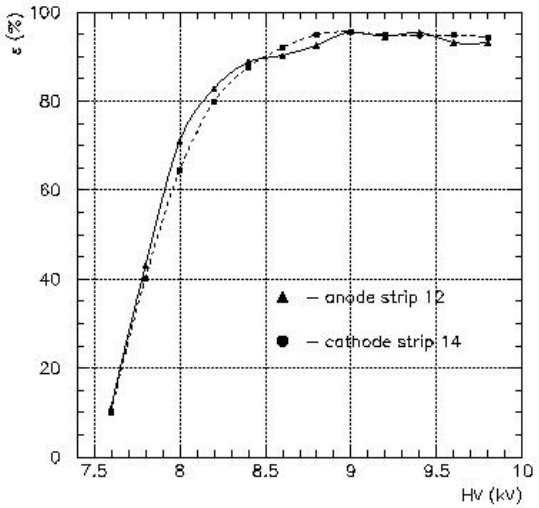
Test of 1 m2 RPC plane

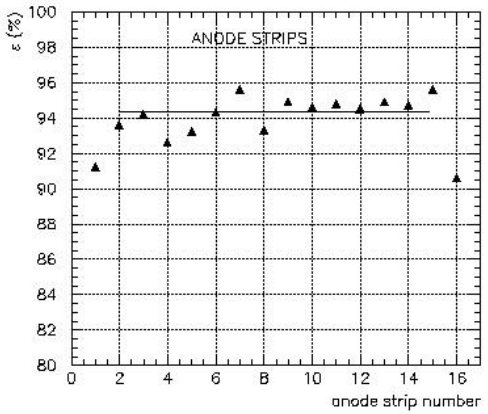
Cosmic ray trigger
Using scint counters
96x6 cm2
2 counters - top
1 counter – bottom

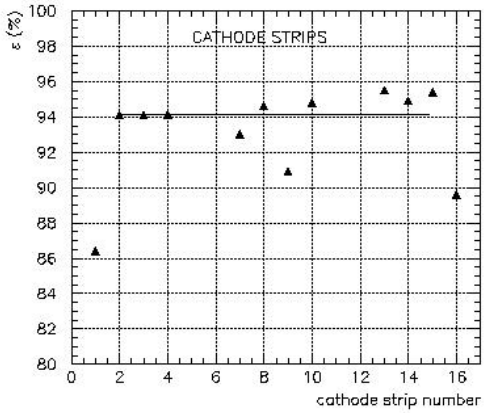
TFE/IB/SF6=90/5/5
gas mixture

1 m3 DHCAL prototype

Test of 1 m2 RPC plane



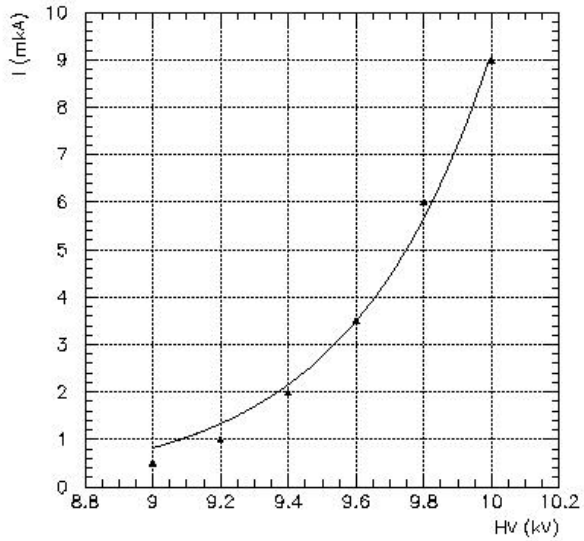




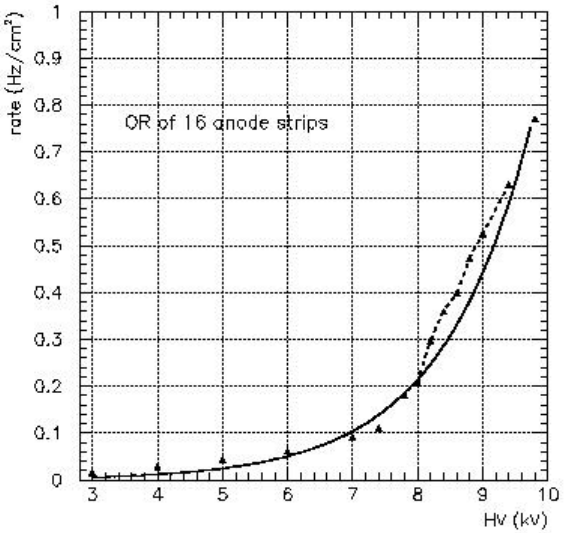
eff ~ 94 %
spread +/- 2% (non uni)

1 m3 DHCAL prototype

Test of 1 m2 RPC plane



Current ~ 1μA/m2
at working HV = 9 kV



Noise rate ~0.5 Hz/cm2
At working HV = 9 kV

Summary

1. **Selection of DHCAL RPC performance**
   1.2 mm monogap glass RPC, saturate avalanche mode
2. **1m2 RPC plane**
   robust design, eff~94%, non uni <2%
3. **Further R&D**
   - 5T mag field test June04
   - Mini DHCAL test in e-beam Dec04
   - production of 40 units of 1m2 RPC planes for 1m3 DHCAL prototype Apr05
   - beam tests of 1m3 DHCAL prototype Dec05