Resistive Plate Counters (RPC)

Past, Present and Future

Mariana Petris, 08.06.2006

Outline

- *Motivation*
- *Short history*
- *SMSMGRPC – Glaverbel Glass Prototype*
  - *Construction Details*
  - *^{60}Co Source Test*
  - *In-Beam Test*
- *Conclusions and Outlook*

Time of Flight (ToF) resolution

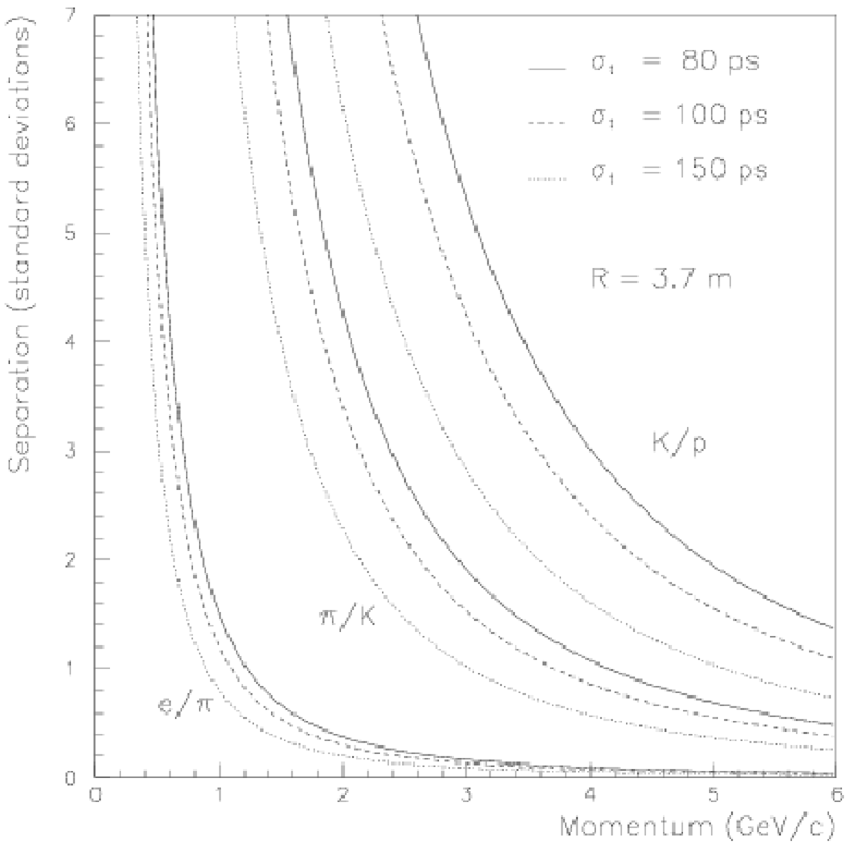
$$\sigma_{ToF} = \sqrt{\sigma^2_{START} + \sigma^2_{STOP}}$$

∀ σ_{ToF} :Time of Flight method resolution

∀ $\sigma_{ToF} \leq 100$ ps for 4σ K/π

∀ σ_{STOP} :Stop counter resolution < 100 ps

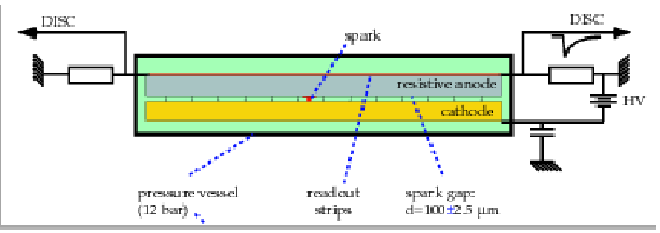
∀ σ_{START} :Start counter resolution <100 ps



Timing Performance of MSMGRPC for MIPs

Status of the field in 1999

Pestov Counter



Y.V.V. Pachomchuck et al. ,
Nucl. Instr. And Meth. A
93(1971) 269

<u>Advantages:</u>

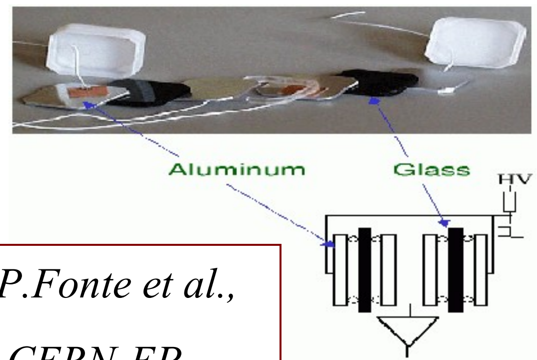
-Very good σ_t (~25 ps)

- Position information: x, y

<u>Drawbacks</u>:

- high pressure operation
- tails in the time spectrum
- needs special glass

Single Cell RPC



P.Fonte et al.,

CERN-EP

27/9/99

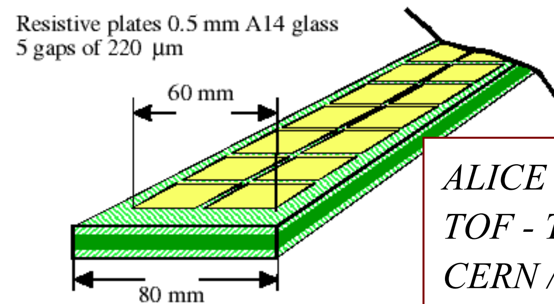
<u>Advantages:</u>

- Very good σ_t (~44 ps)
- commercial glass
- 1 atm pressure operation

<u>Drawbacks:</u>

- edge effects
- unrealistic for large area configuration

MGRPC - pad rows readout



ALICE
TOF - TDR
CERN /
LHCC
2000-12

<u>Advantages</u>:

- Very good σ_t (~60 ps)
- commercial glass

-1 atm pressure operation

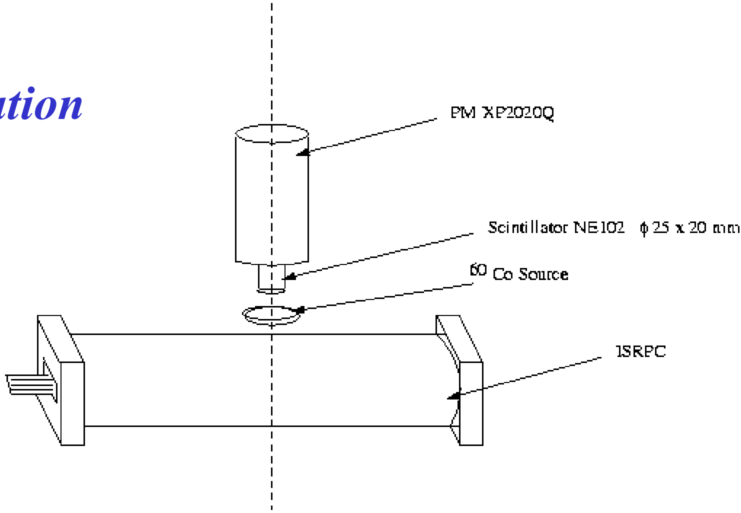
<u>Drawbacks:</u>

- edge effects, cross talk
- no position information over the pad sizes; tracking device is needed for position dependence correction

Our proposal for a MSMGRPC

First prototype , 30 cm length, built and tested in 2000 with ^{60}Co source

- *commercial glass*
- *atmospheric pressure operation*
- *position information: x, y*



•*Amplitude measurements*

FEE

- *Fast Charge Amplifier + Shaping Amplifier (0.25 μ s)*

Digitization

- *Ortec AD811 ADC*

•*Time measurements*

FEE

- *FTA (GSI 80's generation) +CF4000 Discriminator*

Plastic scintillator (NE102)

- *XP2020 PM+ - CF4000 Discriminator*

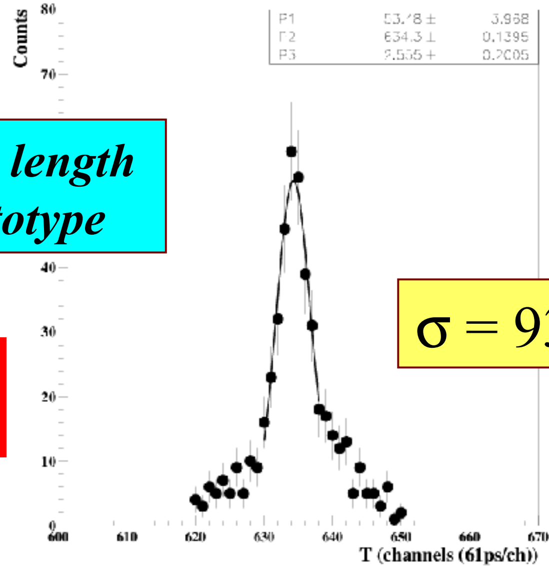
Digitization

- *LeCroy 2228A TDC*

First tests – ^{60}Co source - 2000

30 cm length prototype

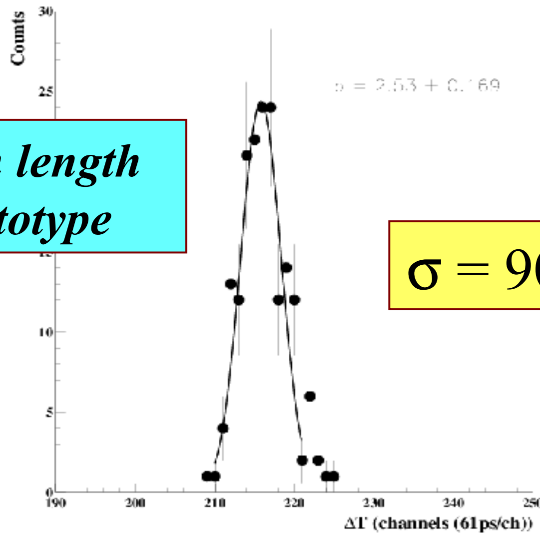
FEE FTA420



σ = 93 ps

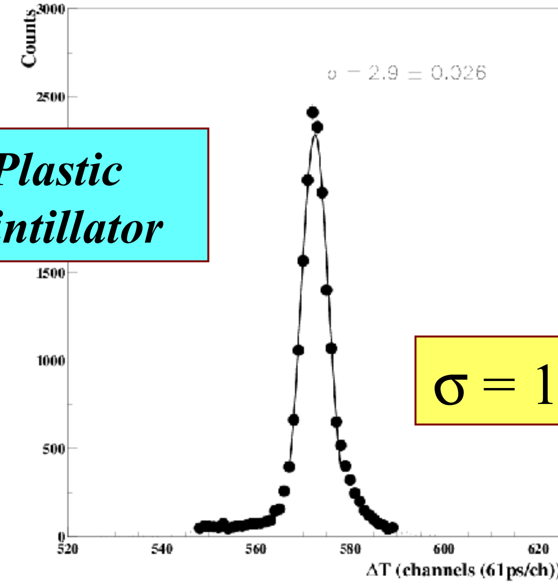
90 cm length prototype

FEE FTA810



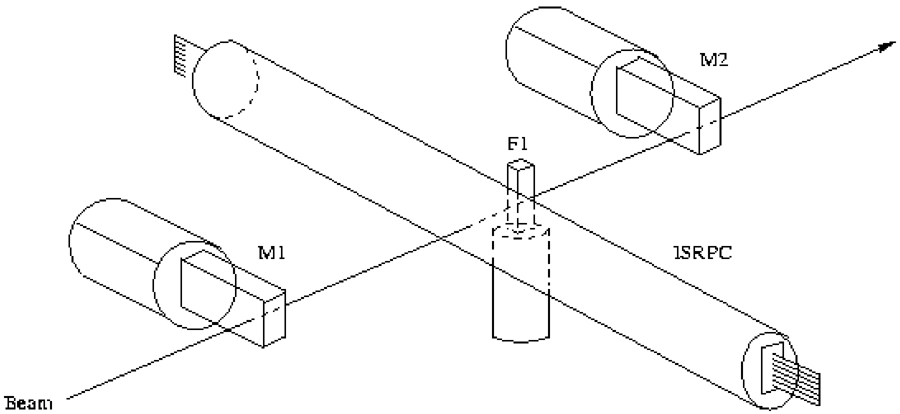
σ = 90 ps

Plastic scintillator



σ = 125 ps

In Beam Tests at the SIS Accelerator of GSI - Darmstadt



Beam: MIPs (p,d 1.5 GeV)

Time reference: 2 crossed scintillators (M1 and M2)

- ***Time measurements***

FEE

- DBA +LE CES-510 (CERN) Discriminator

Plastic scintillator

- CF4000 Discriminator

Digitization

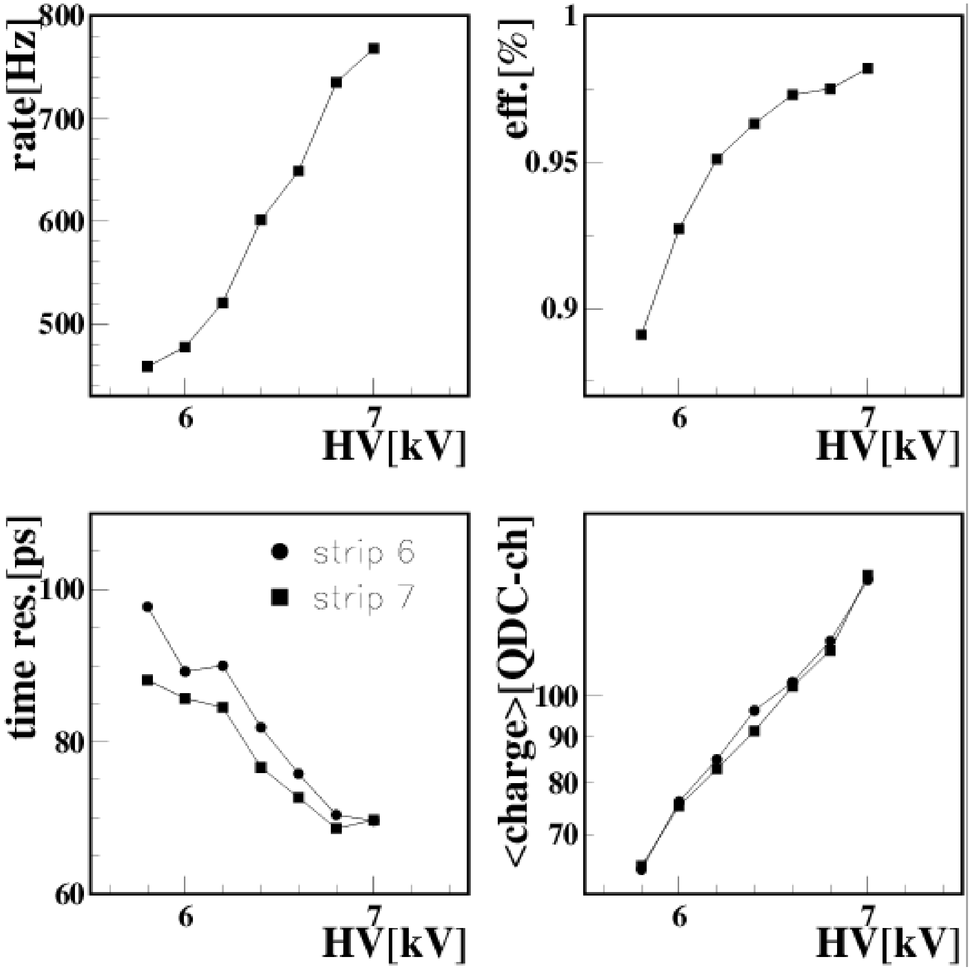
- LeCroy 2228A TDC

- ***Amplitude measurements***

Digitization

- LeCroy ADC 2249W

In-Beam Tests – 2001

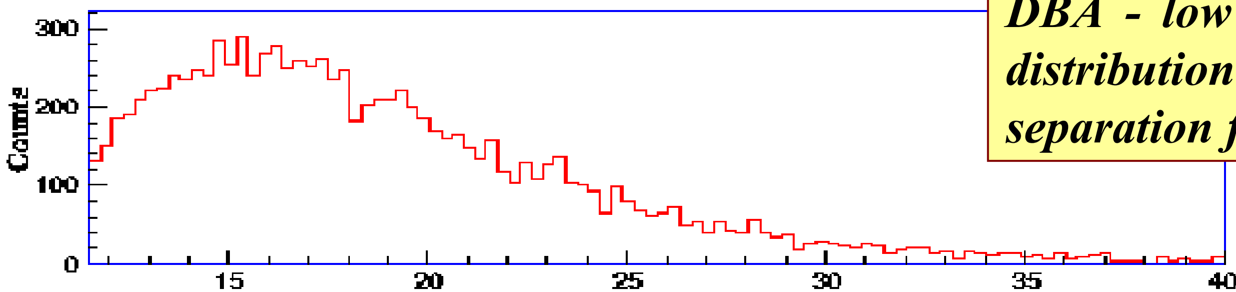


- *The dark rate increases from 3.6 Hz/cm² @ 5.8 kV to 6Hz/cm² @ 7 kV.*
- *For HV > 6.2 kV the efficiency is larger than 95 %.*
- *The time resolution improves from ~ 90 ps @ 5.8 kV to 67 ps @ 7 kV.*
- *The average charge grows almost exponential as a function of HV*
- *The position resolution:*
  - *Along the strip: 5 – 6 mm*
  - *Across the strips: <<1 mm*

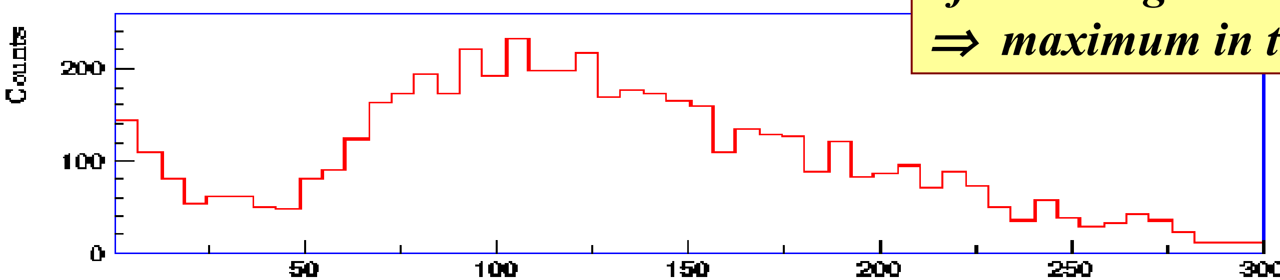
FEE
Cascaded DBAs

- *Nucl. Instr. And Methods, A508 (2003), 75*
- *Nucl. Instr. And Methods, A487 (2002), 337*

Signal Amplification

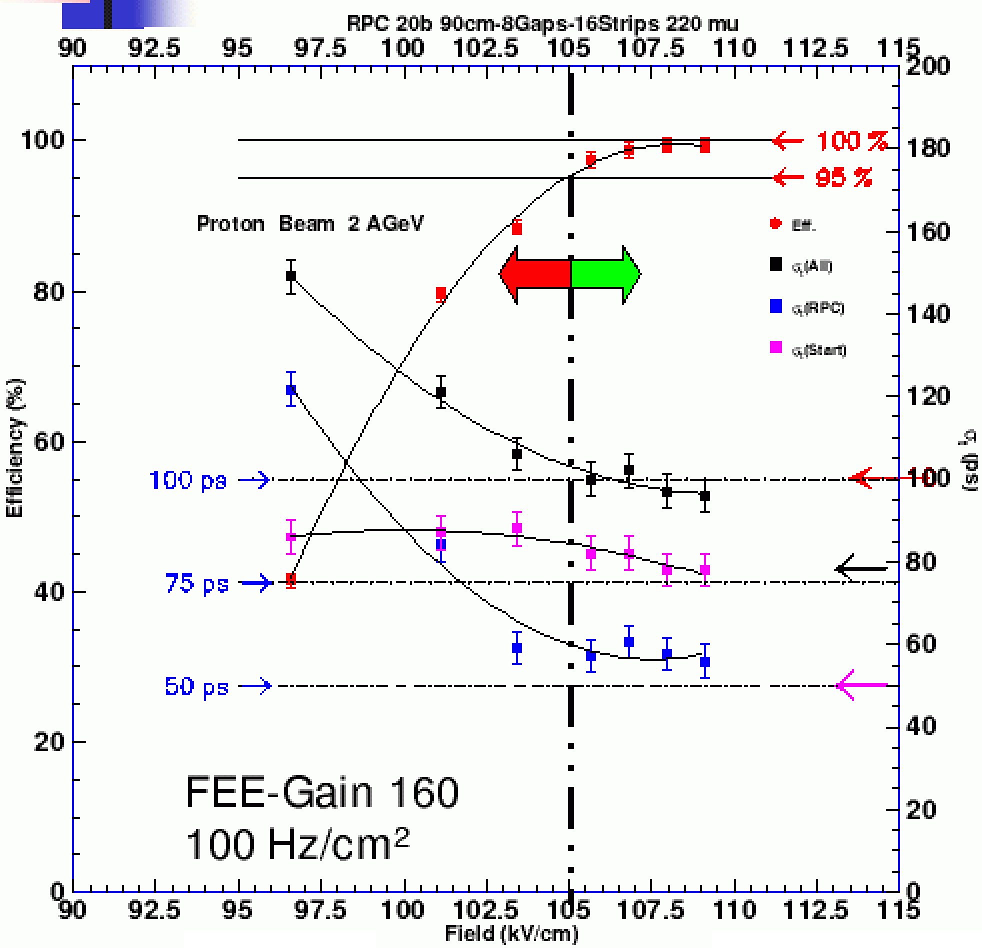


DBA - low gain ⇒ the charge distribution doesn't show a clear separation from the noise



DBA + DBA ⇒ a much better separation of the charge distribution from the noise ⇒ maximum in the efficiency

MMRPC B vs Start



We need a start counter with 50 ps or even better.

For double hits we need a single hit resolution below 80 ps to stay below 100 ps

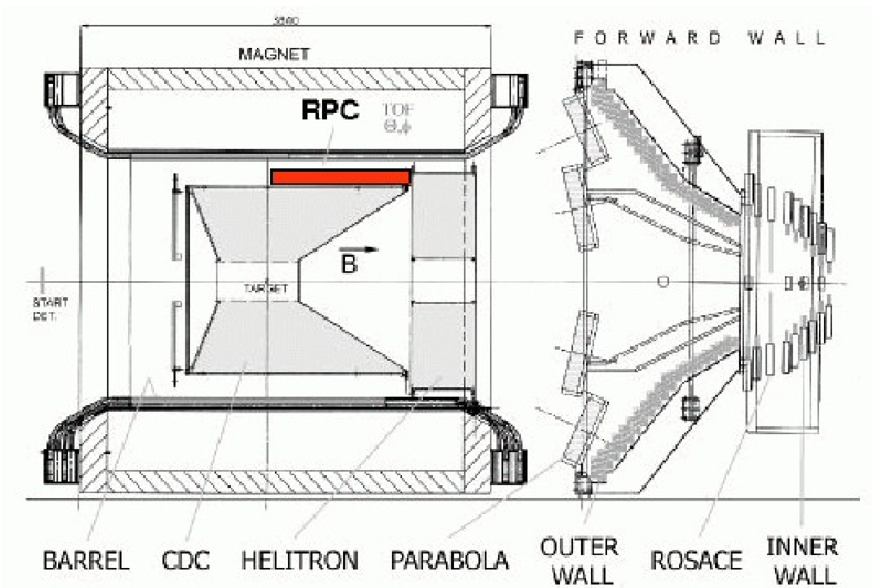
Double hit 100 ps

Single hit 78 ps

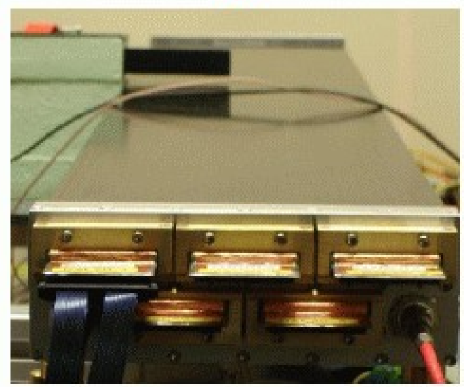
Start 50 ps

RPC$_b$ + Start	$_t$< 96 ps
Start	$_{ts}$< 78 ps
RPC	$_{RPC}$< 56 ps

The upgrading of the FOPI-TOF barrel is based on this type of RPC.

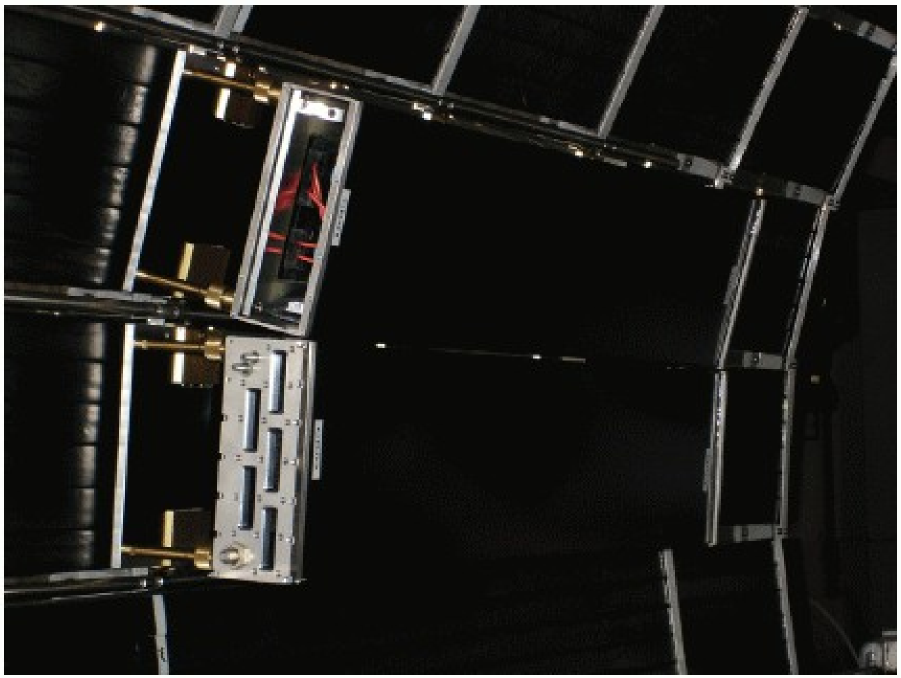


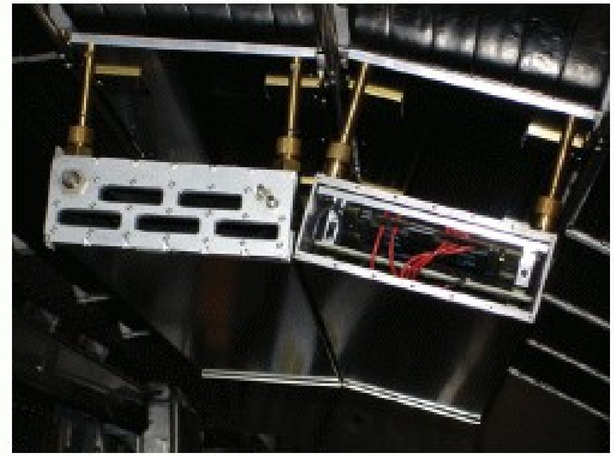
Building SM 0
December 2005



SM 1,2
Januar 2006

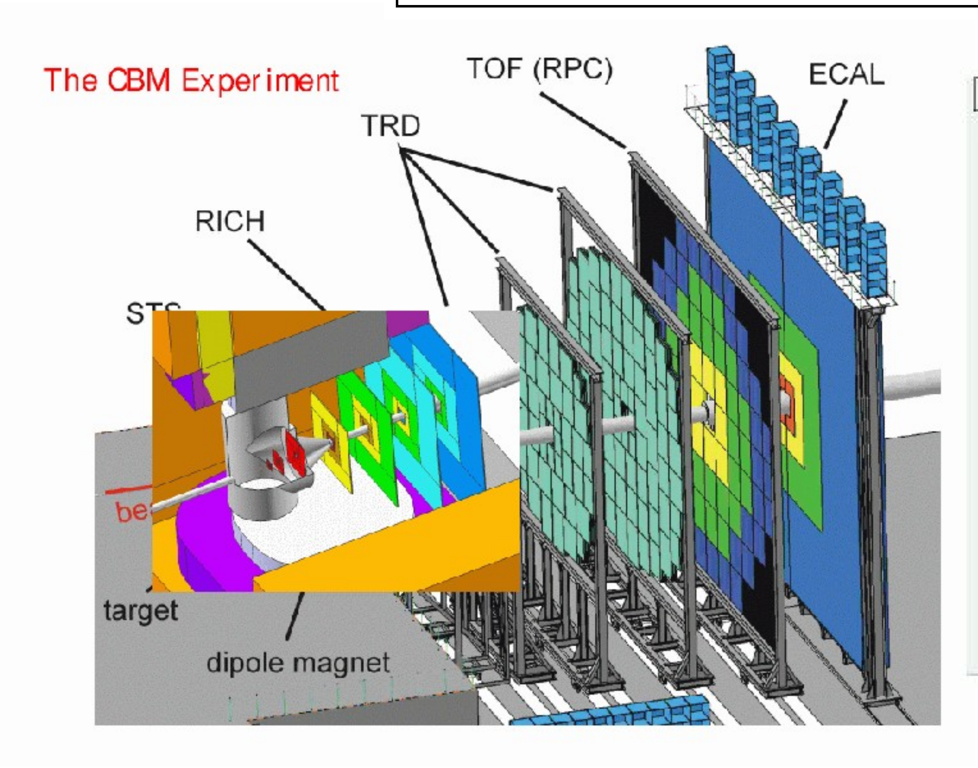
FOPI - TOF SMs

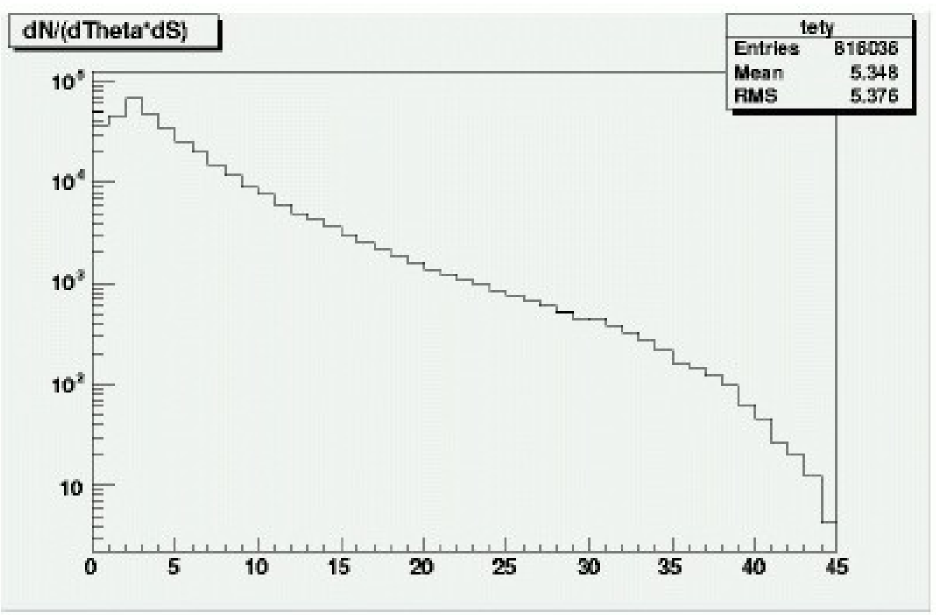




CBM needs on the experiment

- Interaction rate 10^7Hz (~1000 tracks /event)
- TOF wall at 10m from target from 3º to 27º
- Rate from 1kHz/cm^2 (27º) to 20kHz/cm^2 (3º)
  - Hit density from 6.10^{-2}/dm^2 to 1/dm^2 , more than 60000 cells to have occupancy below 5%
  - Total area >60m^2





E. Cordier, CBM Collaboration Meeting, March 2006

SMSMGRPC – Glaverbel Glass Prototype

- ***"Classical SMSMGRPC" keeps the performances up to***

  ~1 kHz/cm² (ρ_{glass} ~ 10^{12} Ωcm)
- ***ToF – CBM subdetector – high counting rate environment (up to 20 kHz/cm² at small polar angles)***
- ***Solutions:***
  - ***Glass electrodes with lower resistivity***
  - ***Smaller and many gaps***
- ***Our prototype was built using glaverbel glass with ρ ~10^{10} Ωcm (as it was specified by the company).***

Construction Details

Electrodes sequence:

- *1.1 cooper foil covered glass – cathode*
- *0.3 nylon fishing line*
- *1.1 glass plate (supporting the spacers)*
- *0.3 nylon fishing line*
- *1.1 glass plate*
- *0.3 double faced strip readout plate*

symmetry plane

Readout electrode:

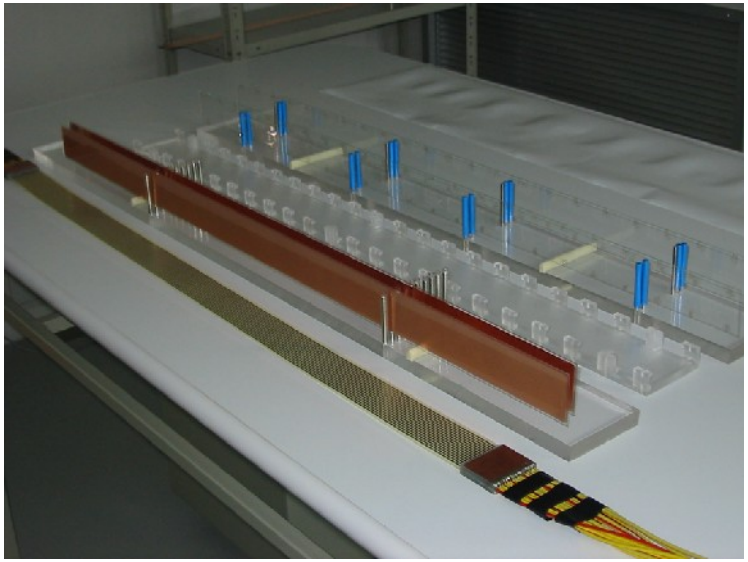
- *support:0.3mm thick pcb plate*
- *16 gold coated strips on each side*
- *pitch: 2.54 mm, 1.00 mm strip width, 1.54 mm gap width*

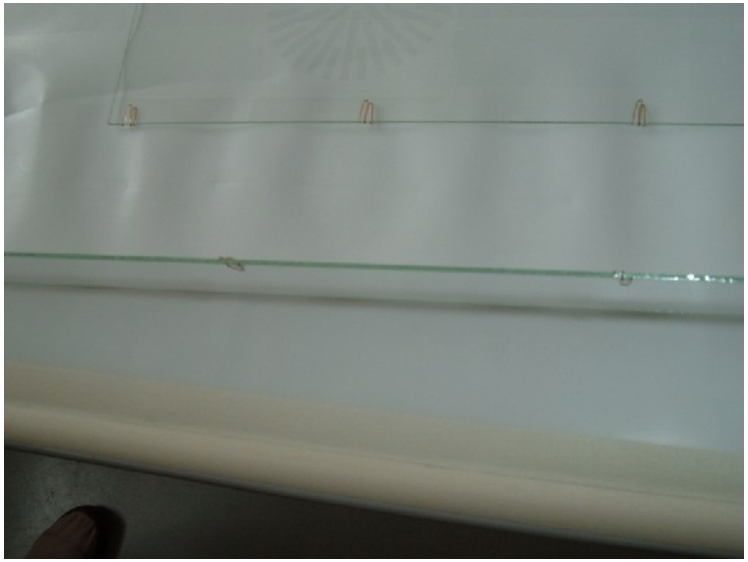
Sizes:

glass electrodes: 46 x 900 mm²

readout plate: 0.3 x 46 x 980 mm³

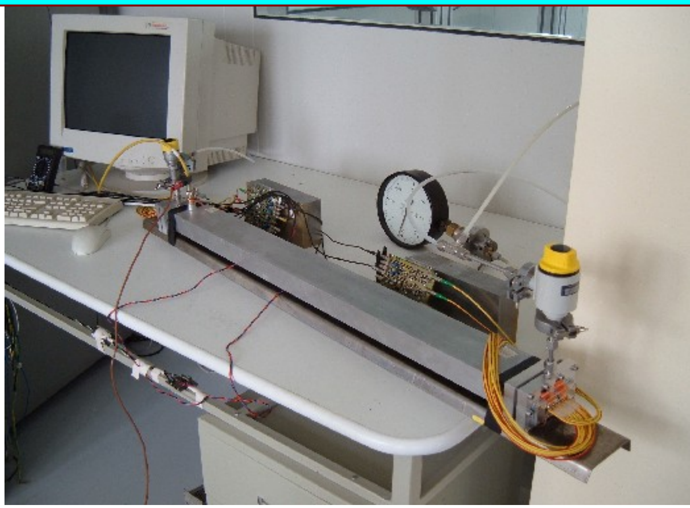
housing: 40 x 80 x 960 mm³ Al box

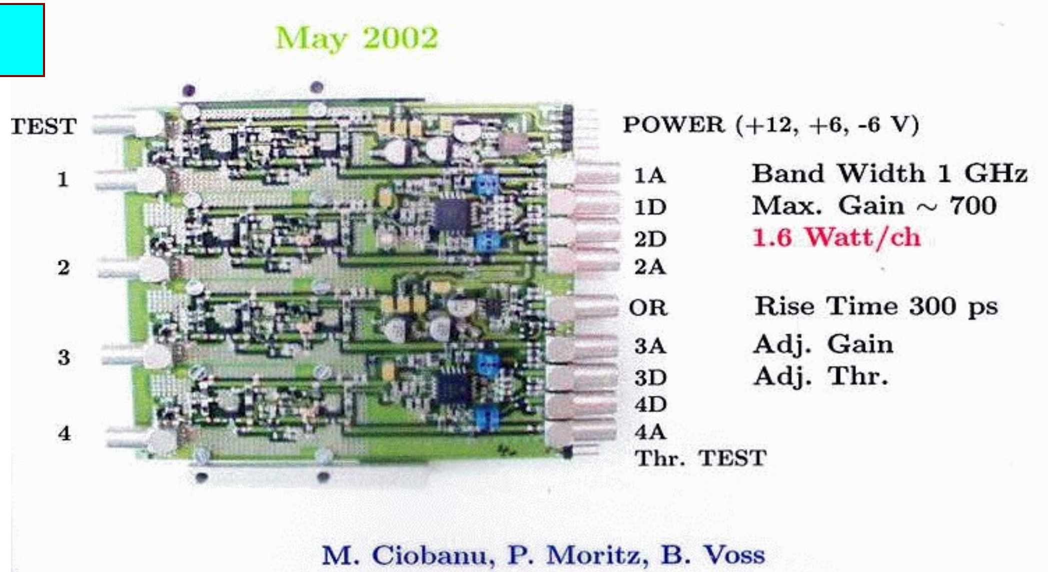


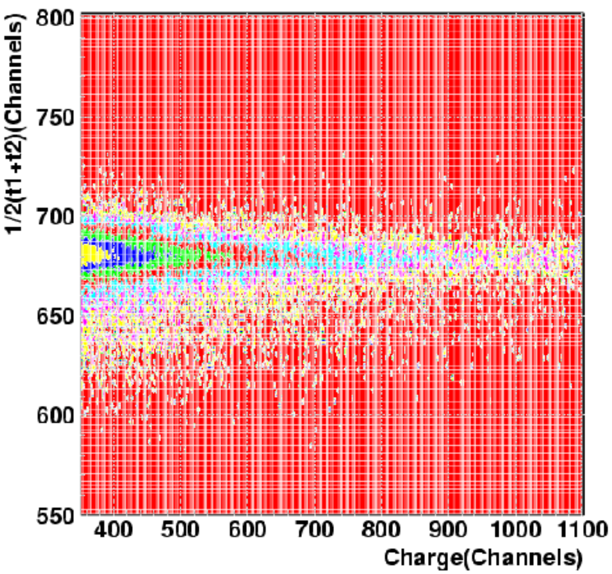


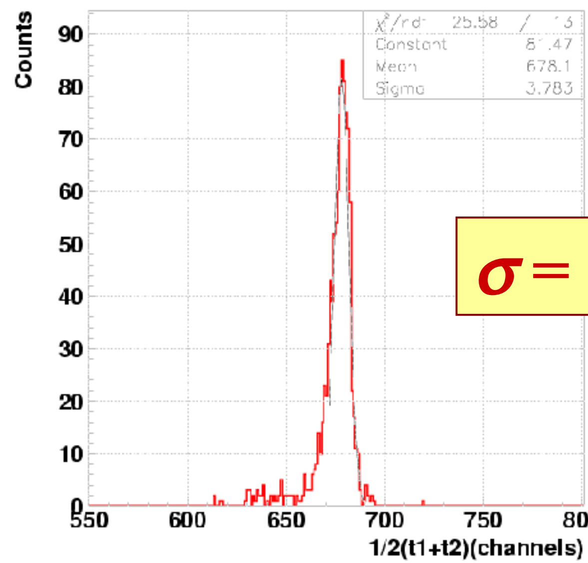
^{60}Co Source Test

85% $C_2F_4H_2$ +10% SF_6 + 5% izo-C_4H_{10}



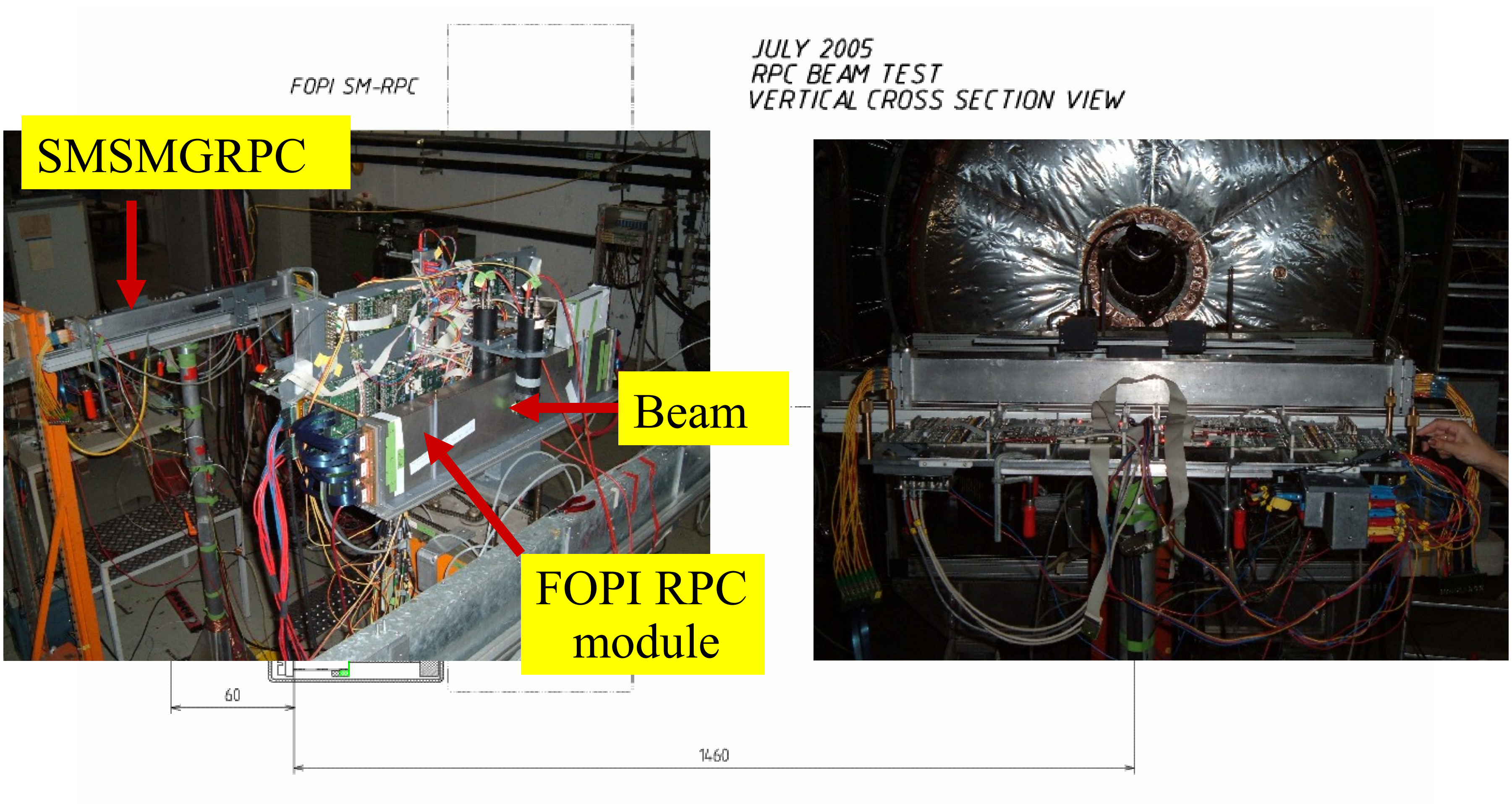






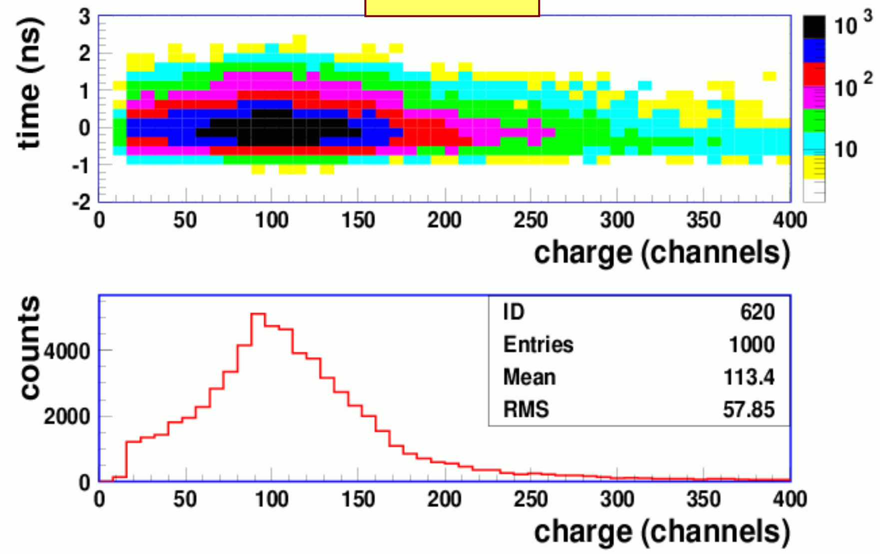
σ = 98 ps

In Beam Test - July 2005
Goal of the experiment – detector performance in high counting rate environment

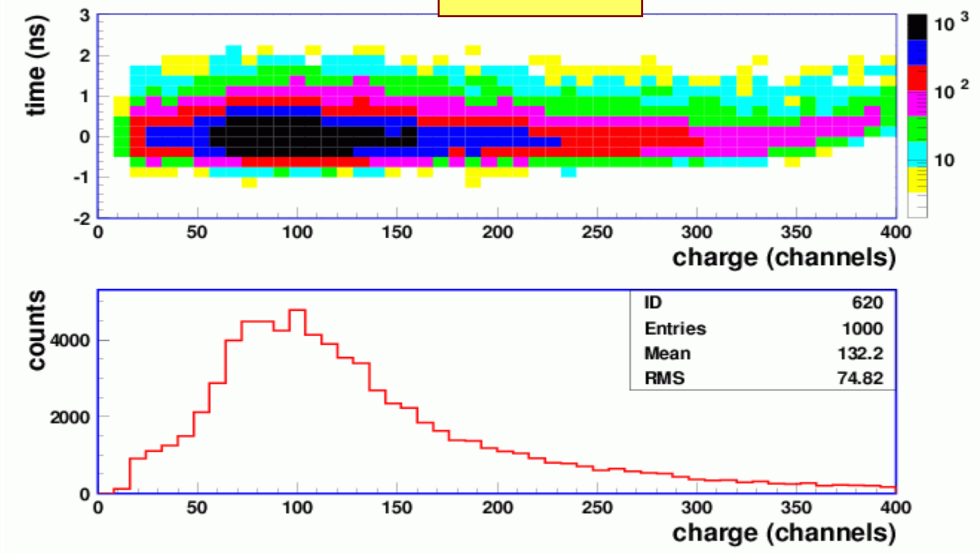


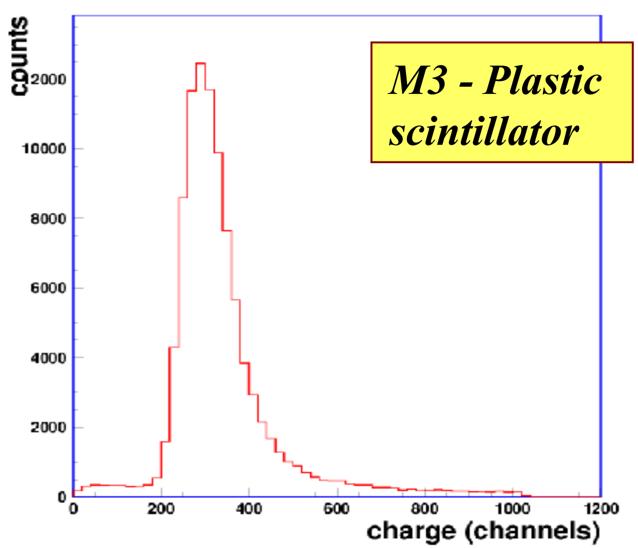
Charge Spectra

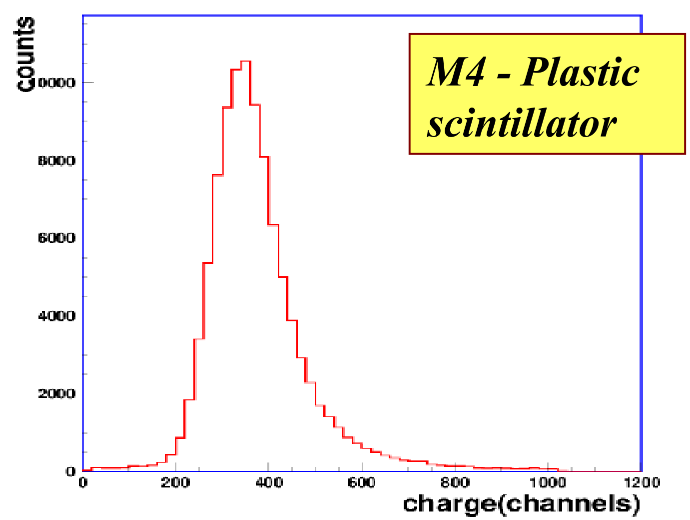
7 kV



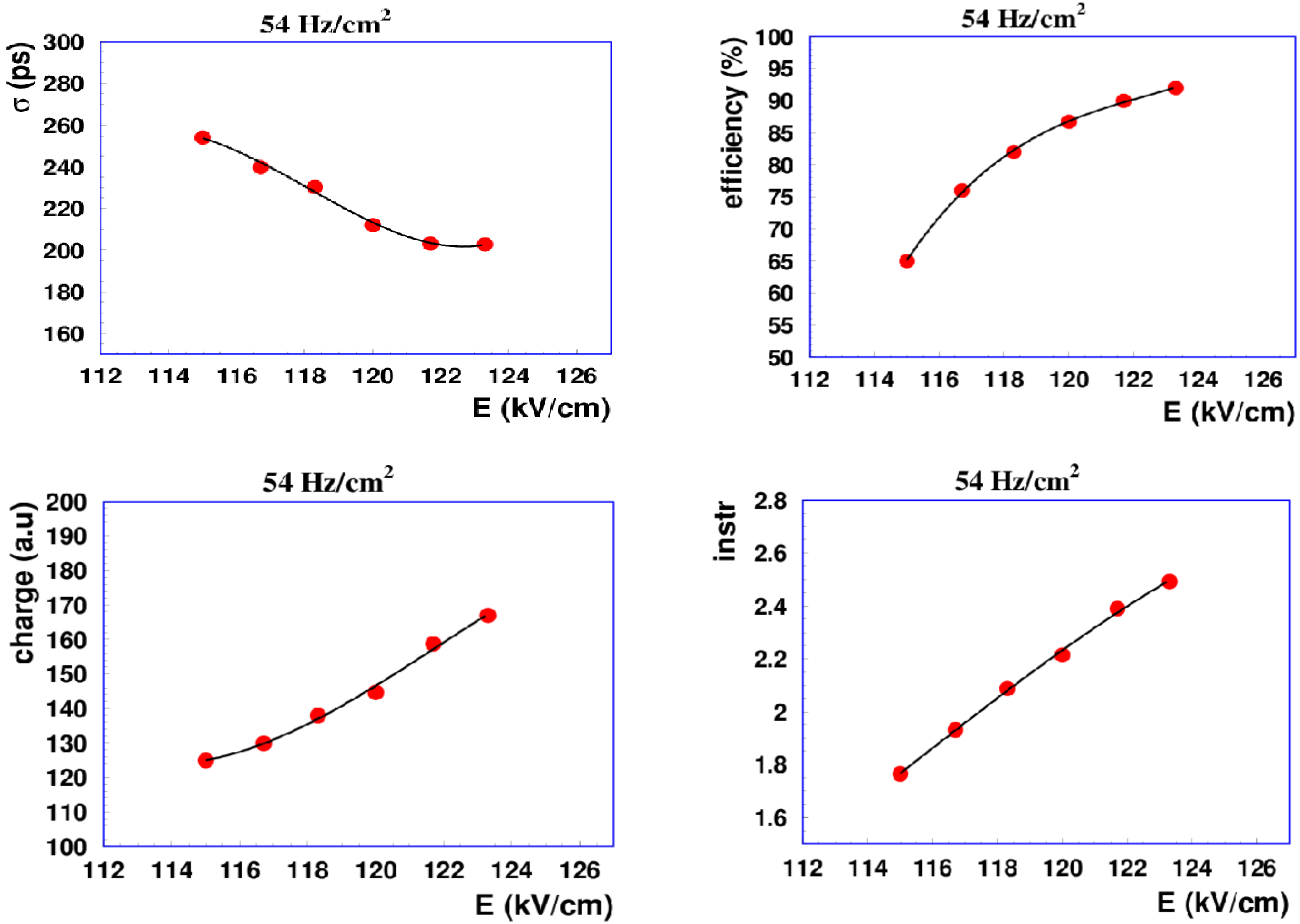
7.4 kV



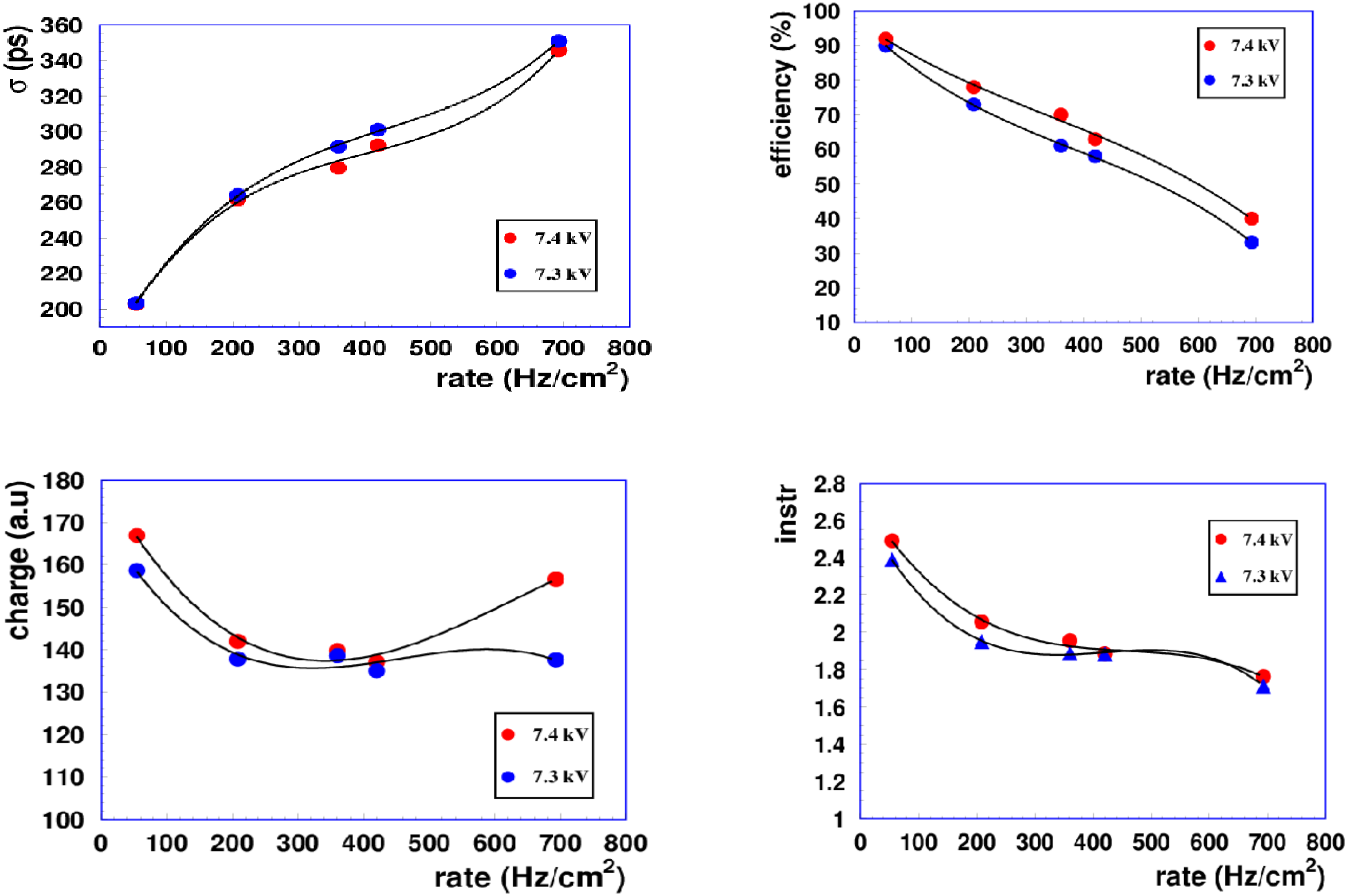




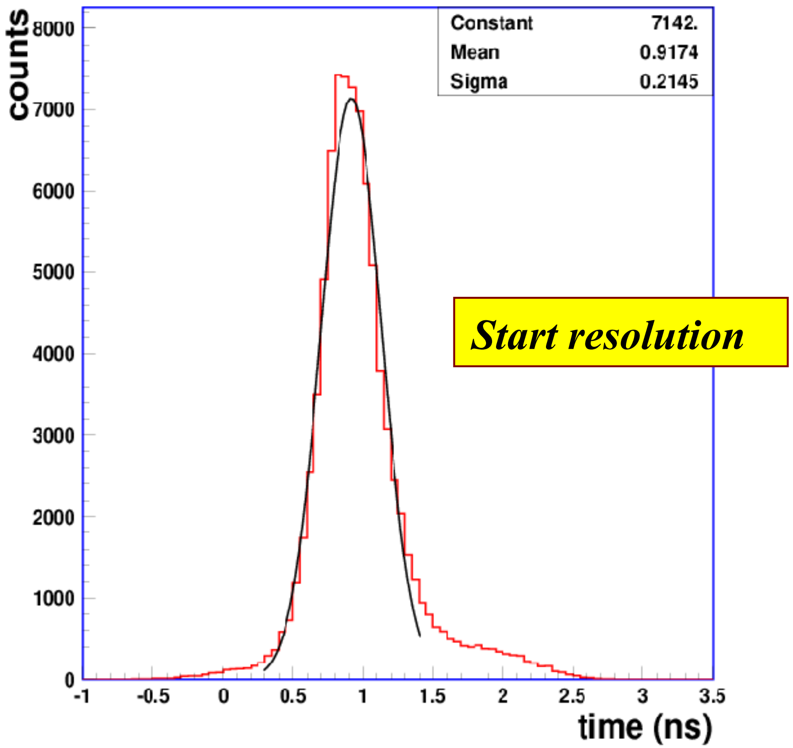
Parameters as a function of HV

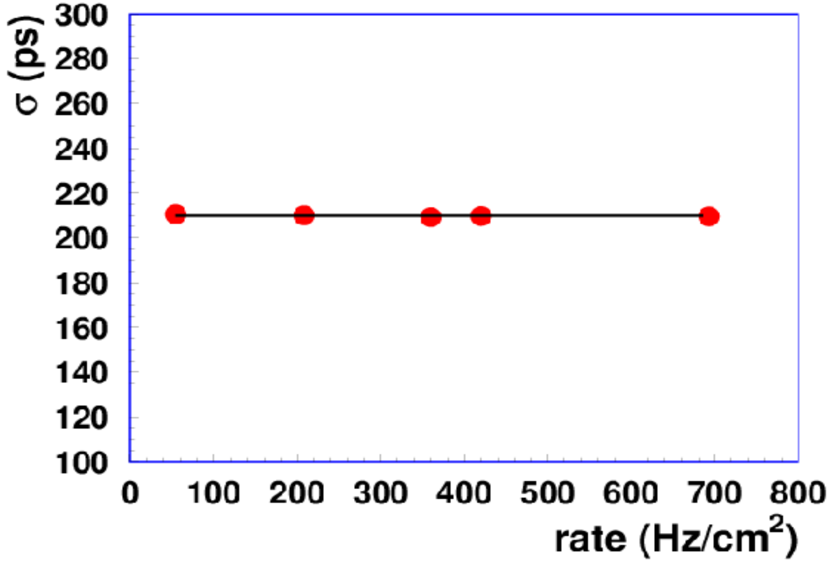


Parameters as a function of rate

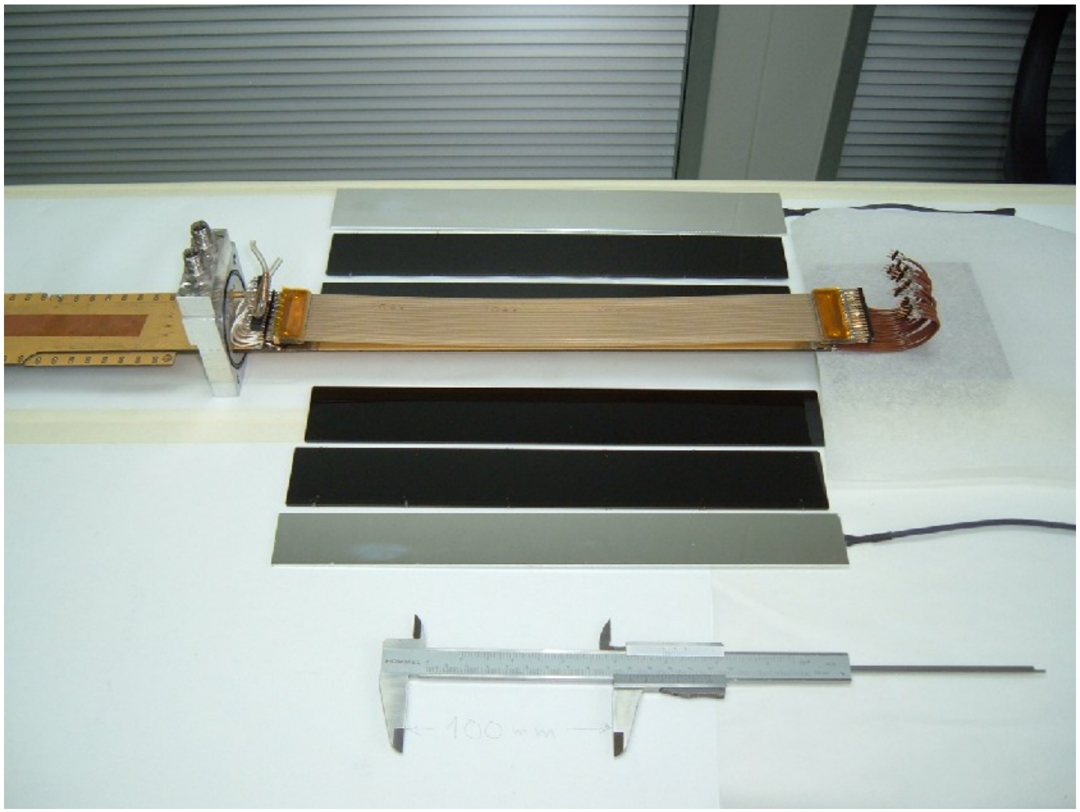


Start Resolution



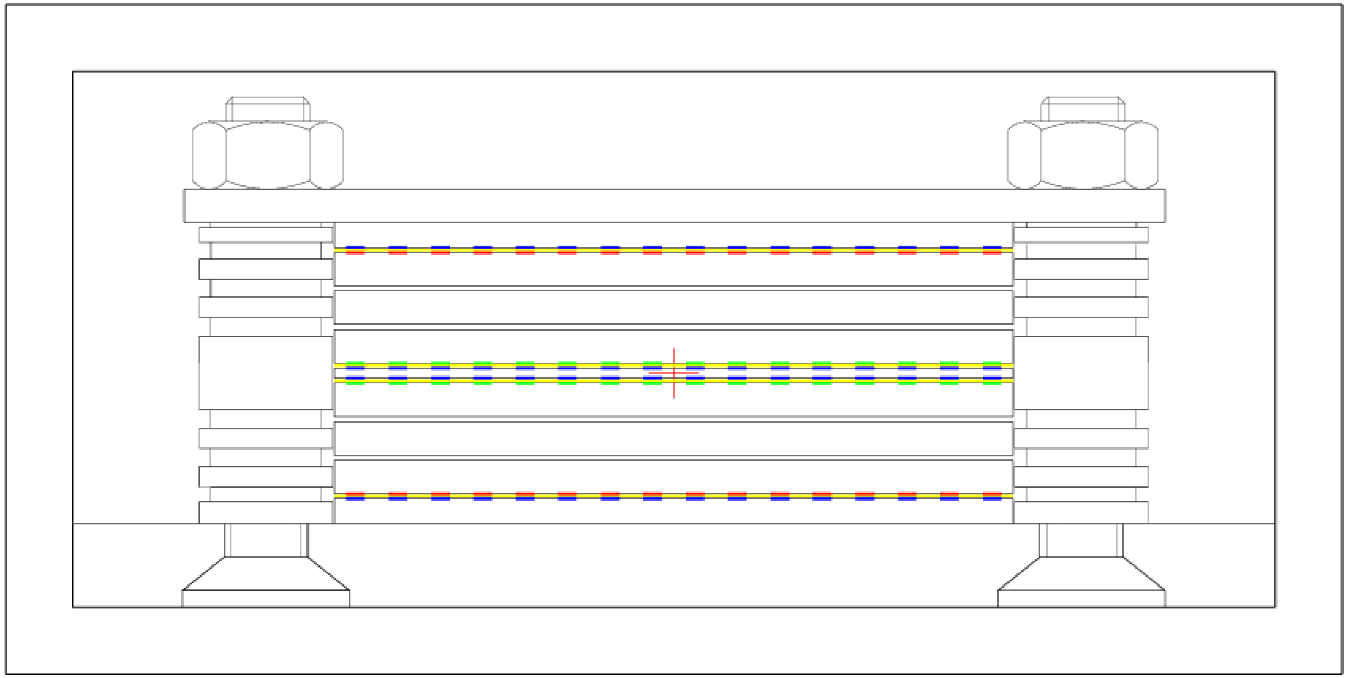


Pestov glass prototype



- ***Pestov glass has a resistivity of ~10^{10} Ω cm.***
- ***It will be tested with the ^{60}Co source in the next days.***

Diferential readout MGMSRPC

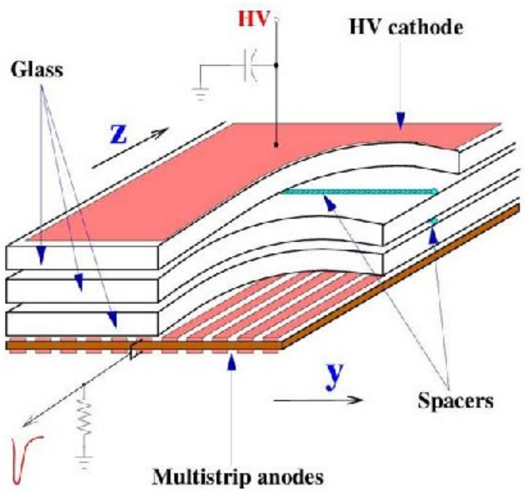


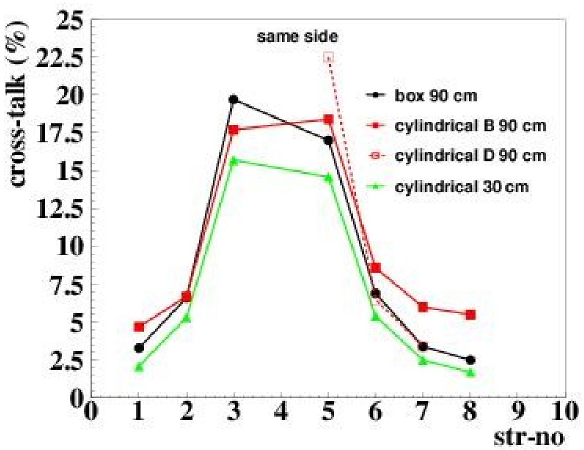
Advantages:
- all troubles related to the impedance mismatches should be eliminated
- the FEE is not affected by discharges
-reduced cross-talks

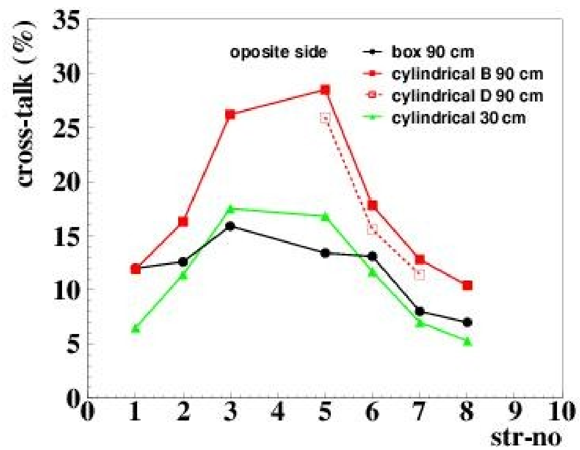
-first preliminary electronic tests were reported @ FOPI Trakoscan Meeting-2002

Differential Strip RPC

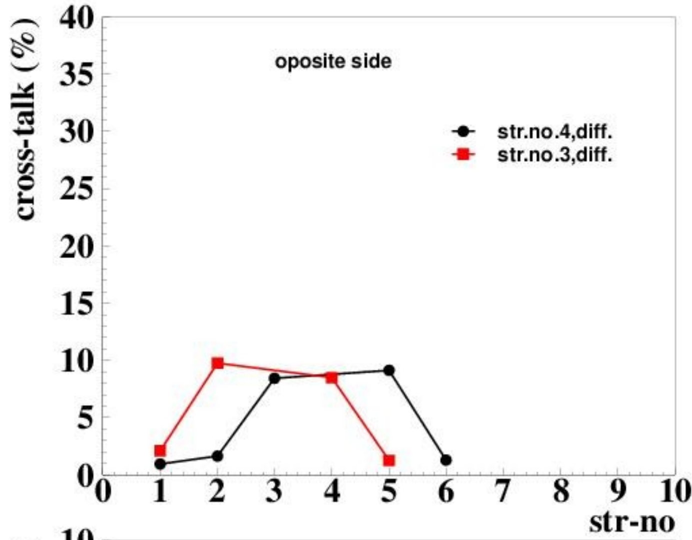
Standard Strip RPC

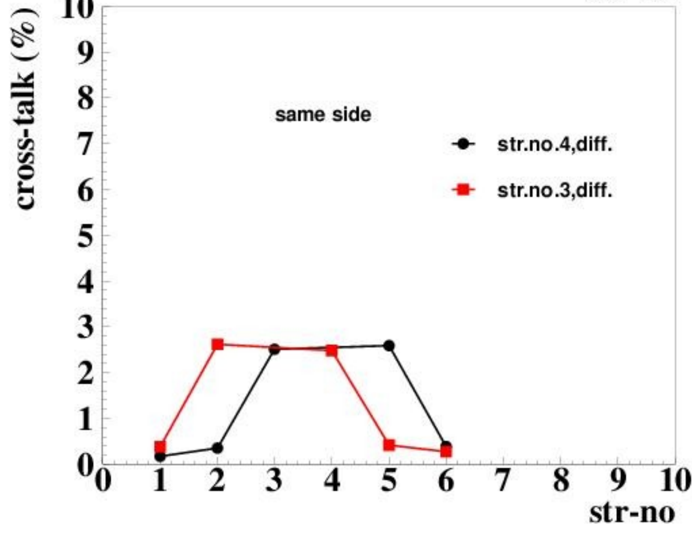






Differential Strip RPC





Conclusions and outlook

- *The first prototypes built and tested with ^{60}Co source by us showed that MSMGRPC design works; their performances were confirmed by in beam tests at the SIS accelerator at GSI Darmstadt, in real conditions, with minimum ionizing particles.*

✓ *The upgrading of the FOPI-TOF barrel is based on this type of RPC.*

✓ *Based on the results obtained with these first prototypes, we have been involved in JRA12-I3HP from FP6.*

✓ *This type of RPC could be a solution for a major part of the TOF – CBM subdetector.*

- *We built, using Glaverbel glass,a new RPC prototype for high counting rate environment (as in CBM - experiment); the observed trends are due to a combined effect of counting rate & electronics setting. This prototype should be tested again using properly adjusted electronics.*

- *We built a 30 cm new prototype using Pestov glass which we know that has a resistivity of ~10^{10} Ω cm ready to be tested with the ^{60}Co source and in –beam.*

- *We will built a prototype with smaller gaps of 220 µm or 170 µm..*
- *We are on the way to design similar structures with differential readout.*