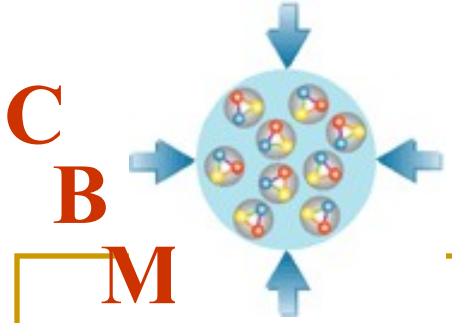
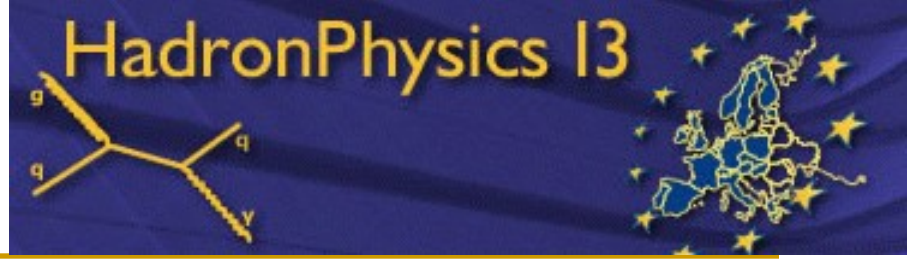




High Efficiency Transition Radiation Detector for High Counting Rate Environment

Mariana Petris

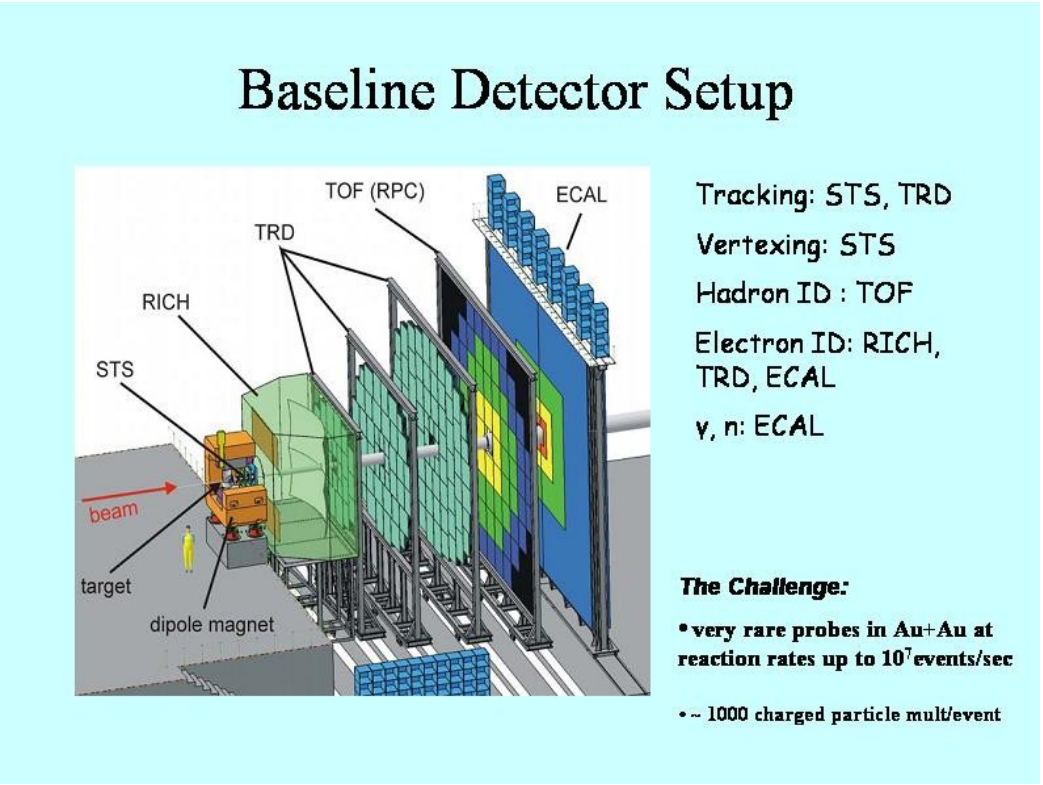
IFIN-HH, Bucharest

12.09.2006

Outline

- *First HCRTRD prototype: short review*
- *Second prototype: Double – Sided HCRTRD*
- *^{55}Fe source tests*
- *In beam tests:*
  - ✓ *investigation of the rate capability*
    - *pulse height and charge*
    - *position resolution*
  - ✓ *e/π discrimination;*
- *Conclusions*

CBM requirements



- **Interaction rate 10^7Hz (~1000 tracks/event)**
- **TRD subdetector:**
  - **3 stations @ 4, 6, 8 m from target (3 layers each)**
- **Highly granular and fast detectors which can stand the high rate environment (up to 100 kHz/cm^2)**
  - **Identification of high energy electrons ($\gamma > 2000$); pion rejection factor ≥ 100**
  - **Tracking of all charged particles: position resolution ~ 200 μm**

High Counting Rate Transition Radiation Detector

	ALICE - TRD	ATLAS - TRT
- type	(radiator+drift chamber + MWPC)	(radiator + straw tubes)
- π_{rej} (at 90% e efficiency)	100	100
- Maximum drift time	2 μs	40 ns
- Counting rates	~ 100 Hz/cm^2	~ 1MHz/ cm^2
- Granularity (cell size)	high (~6 cm^2)	low (~20cm^2)

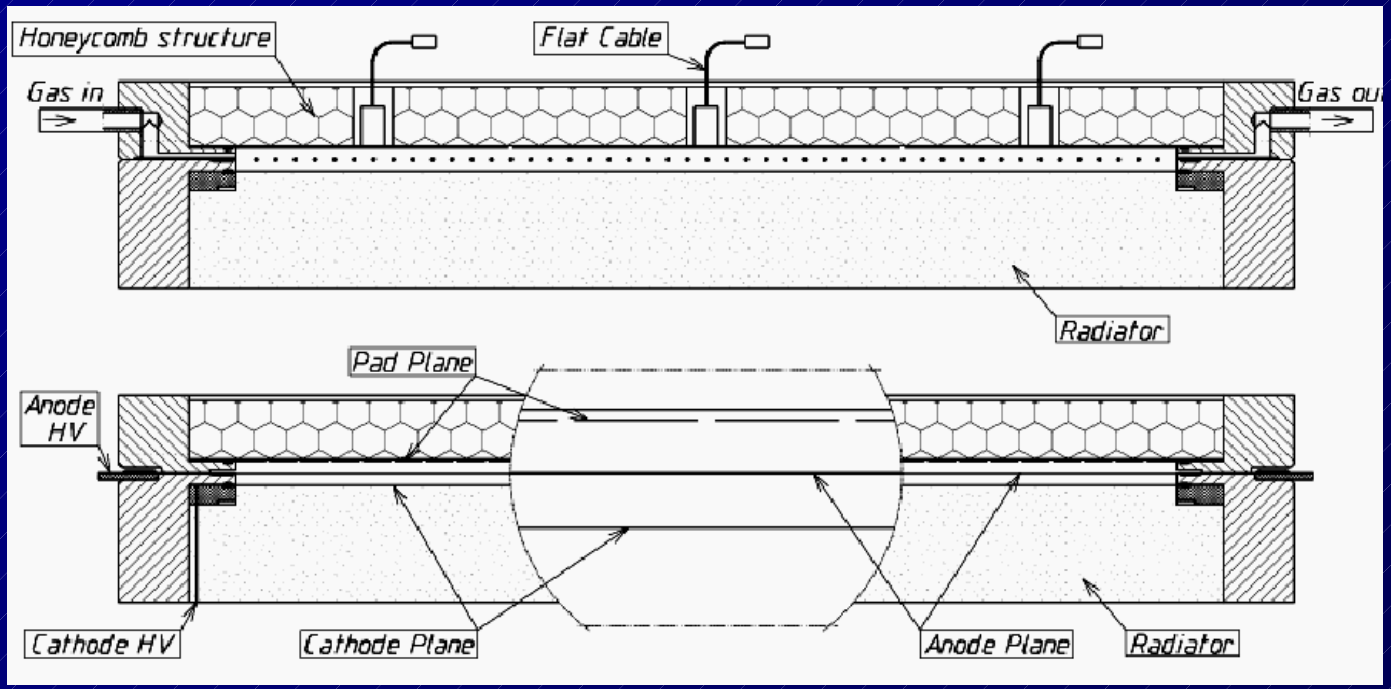
CBM - TRD

Counting rates ~ 100 kHz/cm^2

High granularity

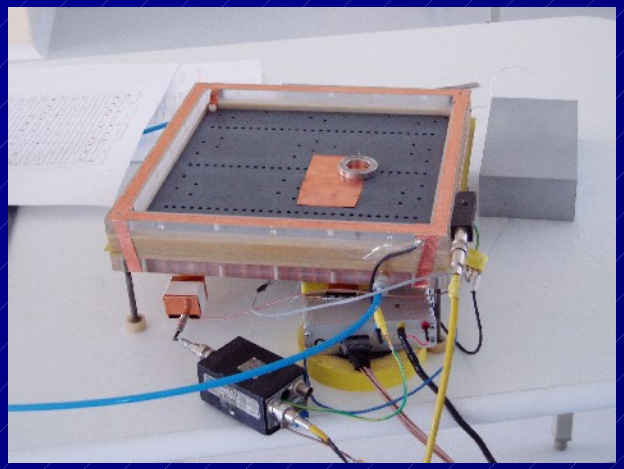
- π_{rej} (at 90% e efficiency) > 100

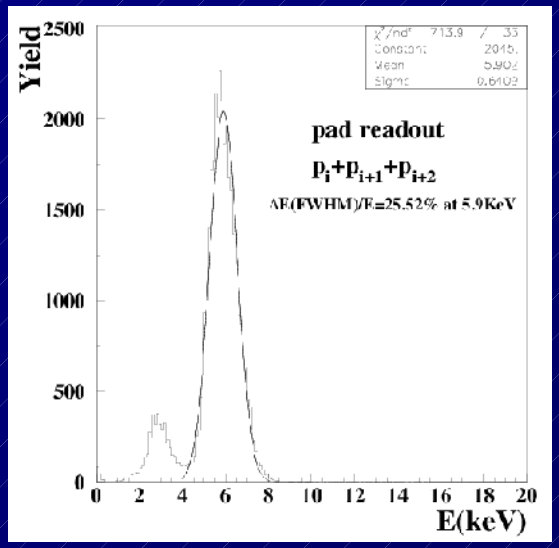
First HCRTRD - prototype

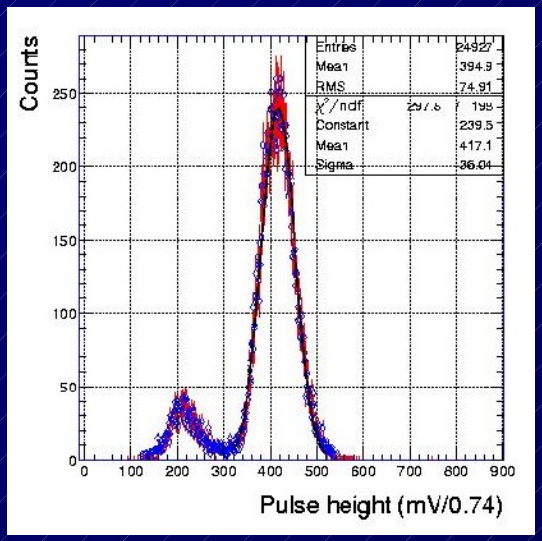


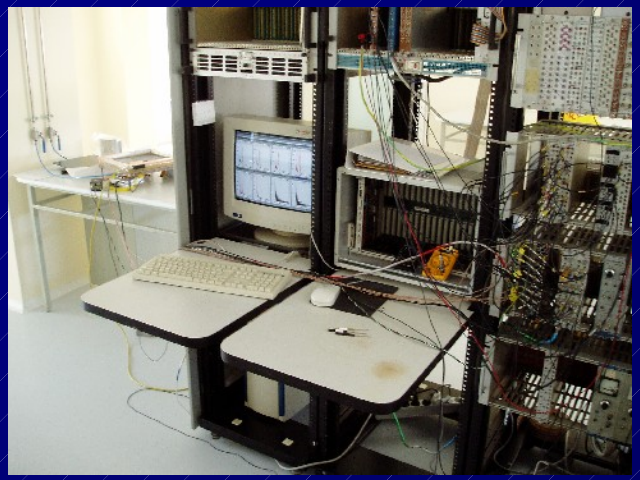
- *type: radiator + MWPC; 2.5 mm anode pitch*
- *maximum drift time ~ 100 ns*
- *cell size ~ 6 cm²*

^{55}Fe Source Tests









IFIN - HH ^{55}Fe tests

30% CO_2 + 70% Ar

HV 1920 V;

Readout: PASA (2 mV/fC, 1800 e rms) + ADC Converter

Energy Resolution :

~10% (σ);

~25% FWHM

GSI ^{55}Fe tests

15% CO_2 + 85% Ar

HV 1700 V;

Readout:PASA (2mV/fC, 1800 e rms) + FADC Converter

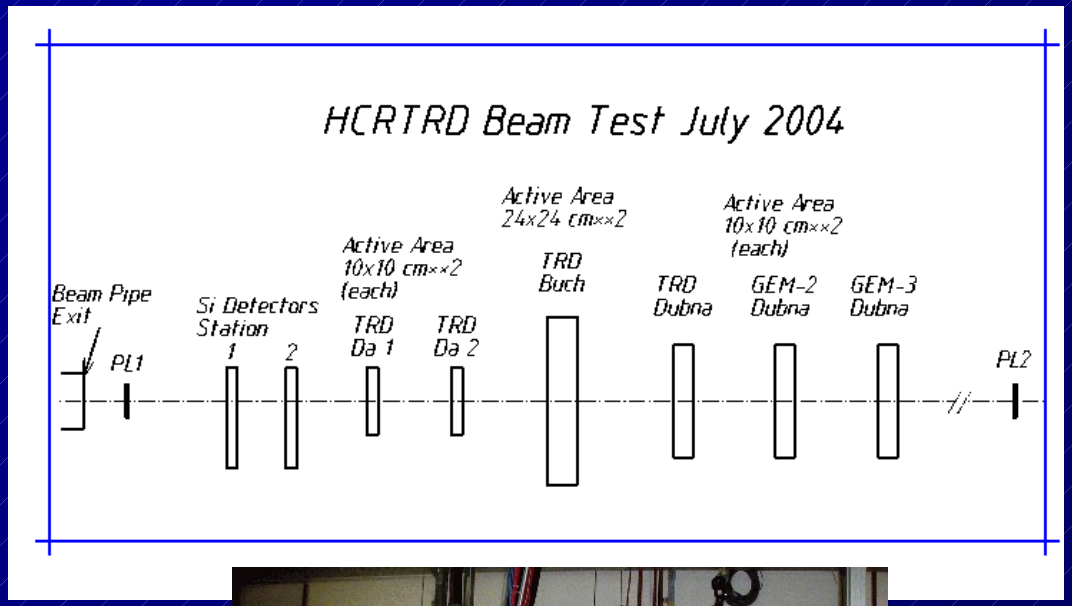
Energy Resolution:

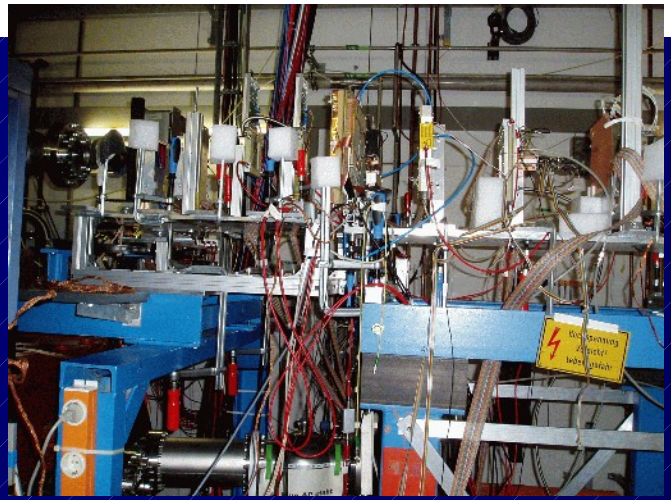
~ 8.6 % (σ);

~20 % FWHM

Beam Test, July 2004

Goal of the experiment: detector performance in high counting rate environment

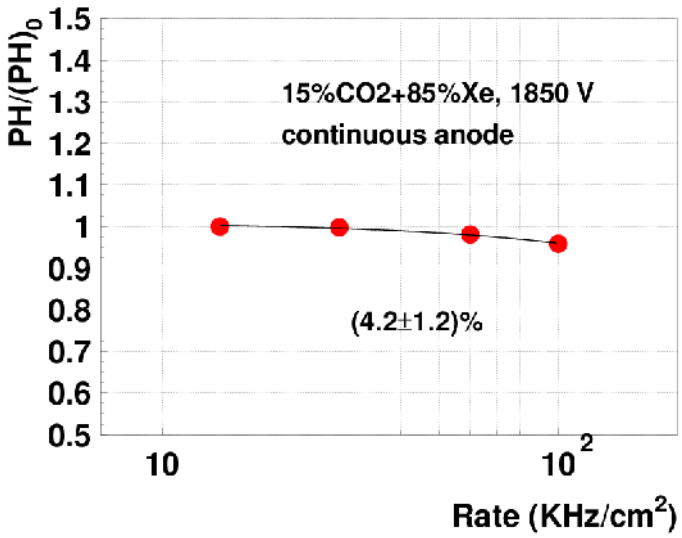


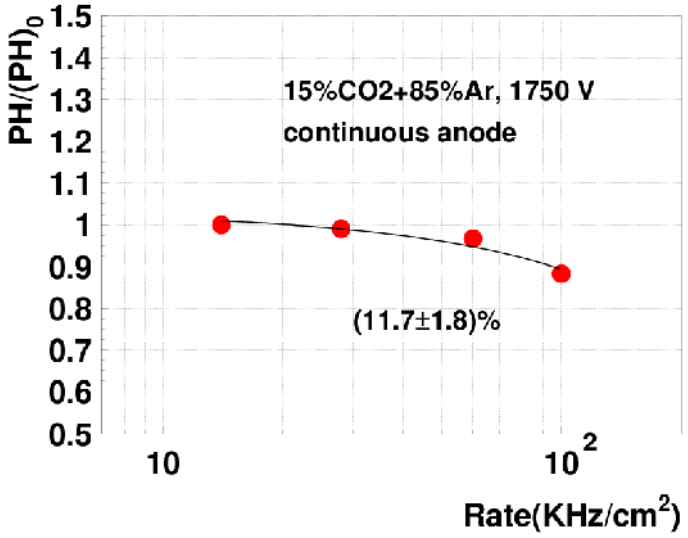


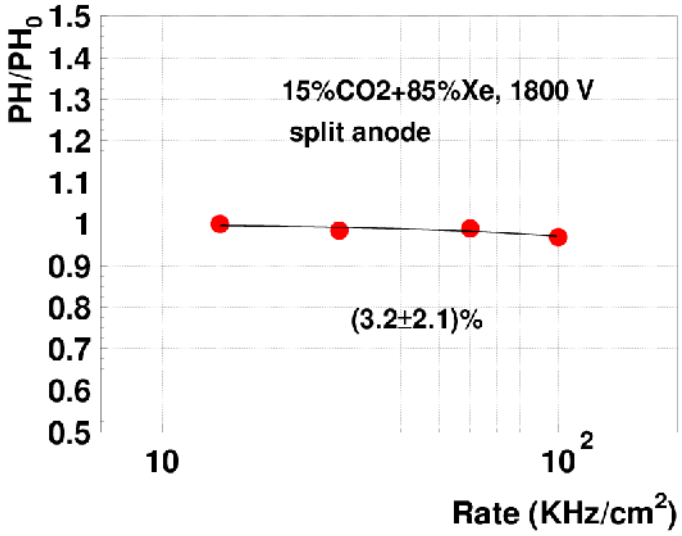
Experimental Setup:

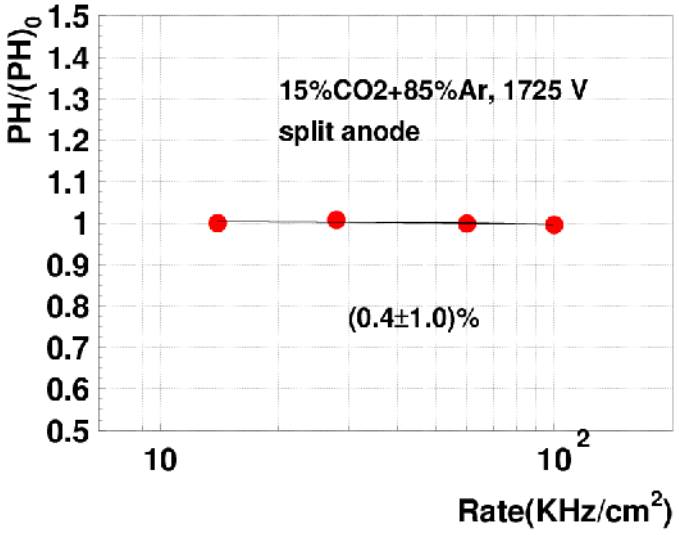
- **2 Scintillators (ToF, trigger);**
- **2 Si - Strip Detectors (position information);**
- **2 MWPC - GSI (10 x 10 cm^2)**
- **1 MWPC - Bucharest (24 x 24 cm^2)**
- **-1 MWPC - Dubna (10 x 10 cm^2)**
- **1 GEM - Dubna**
- **Pb - glass calorimeter (last run)**
- **FADC readout ; DAQ (MBS)**

High Counting Rate Effect
Pulse Height

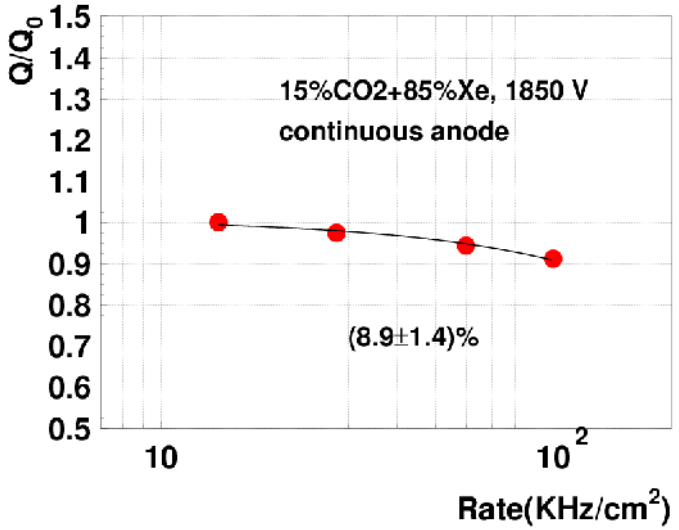


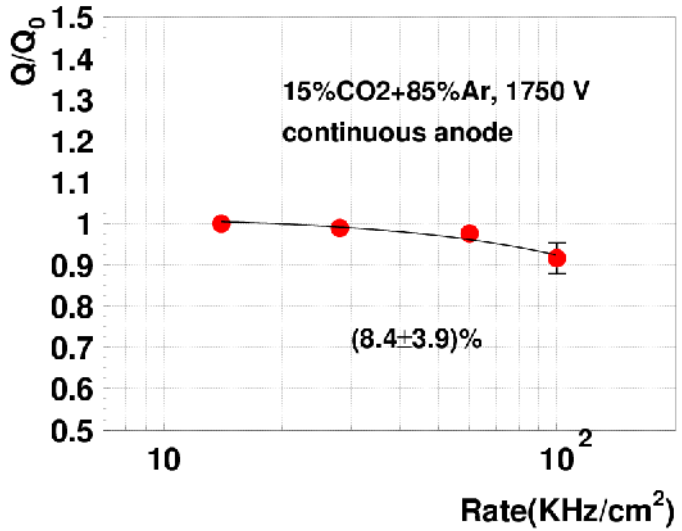


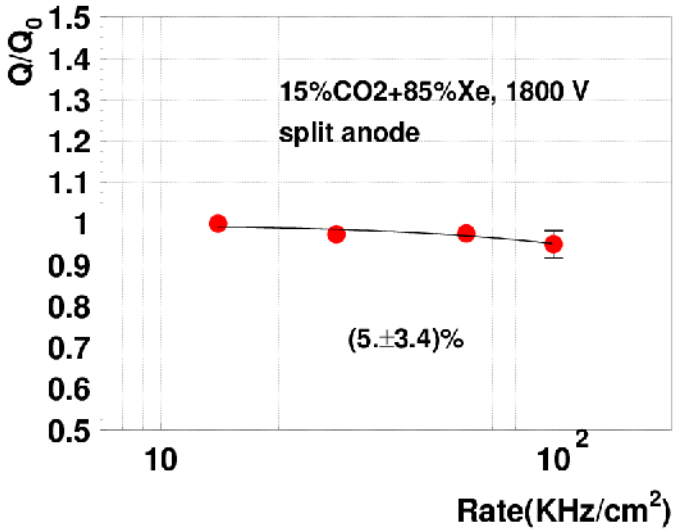


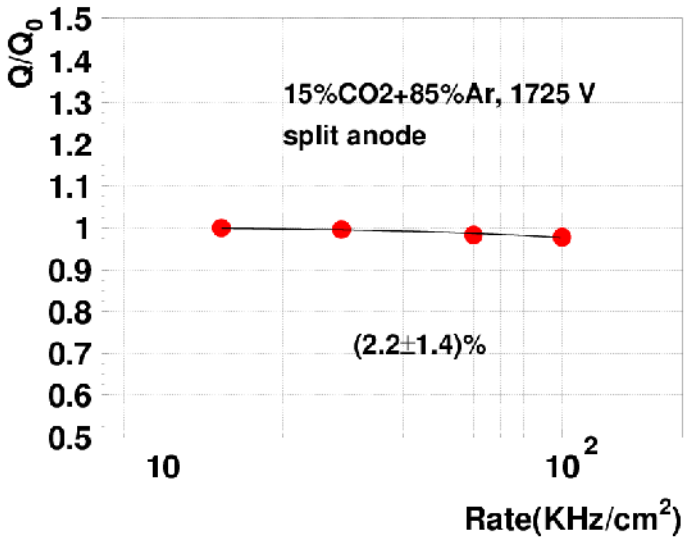


High Counting Rate Effect Charge

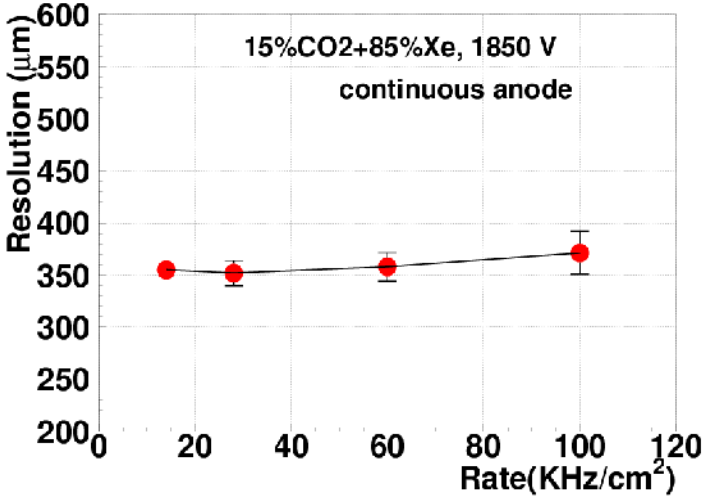


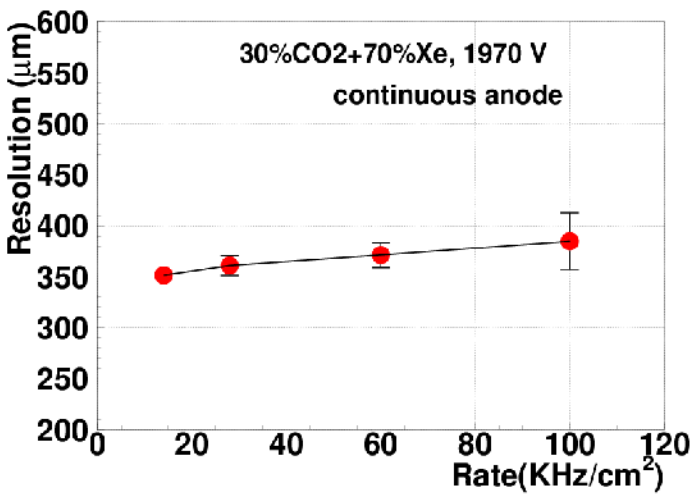


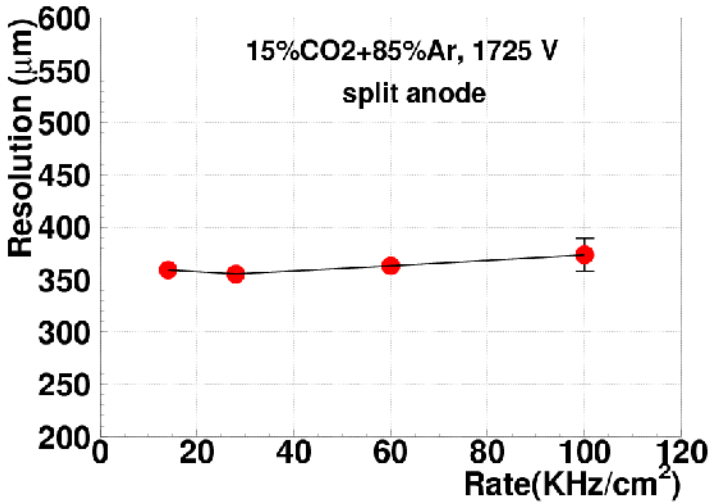


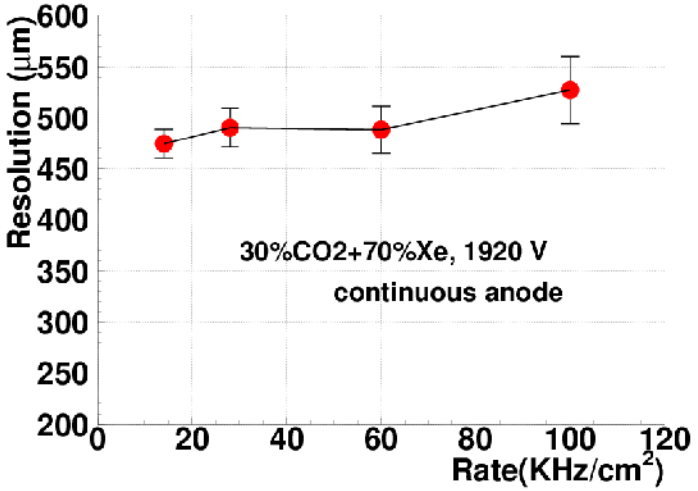


High Counting Rate Effect
Position Resolution

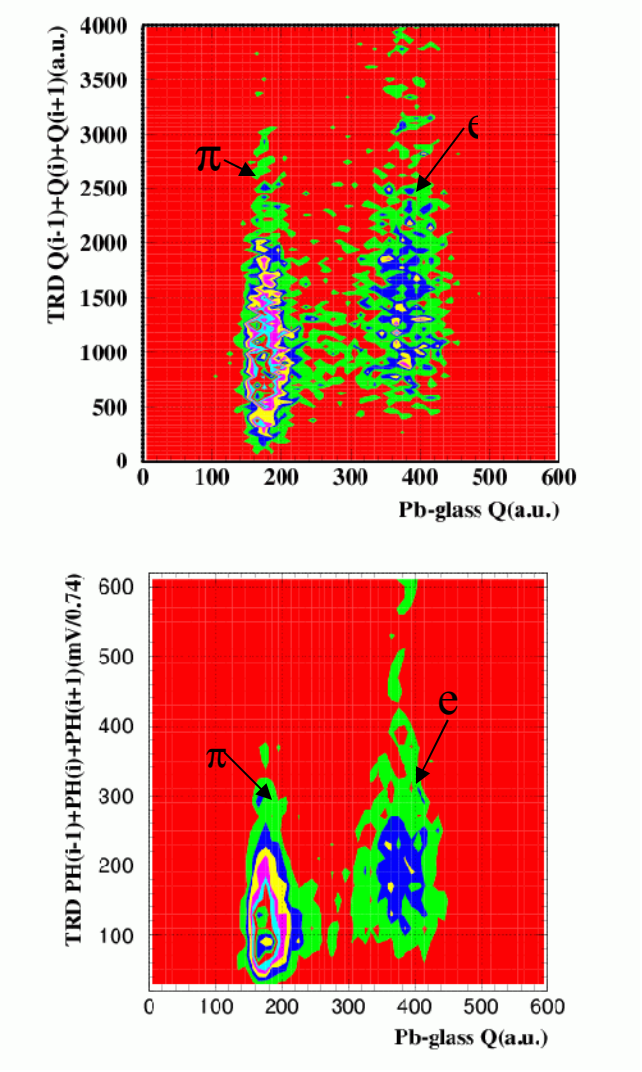


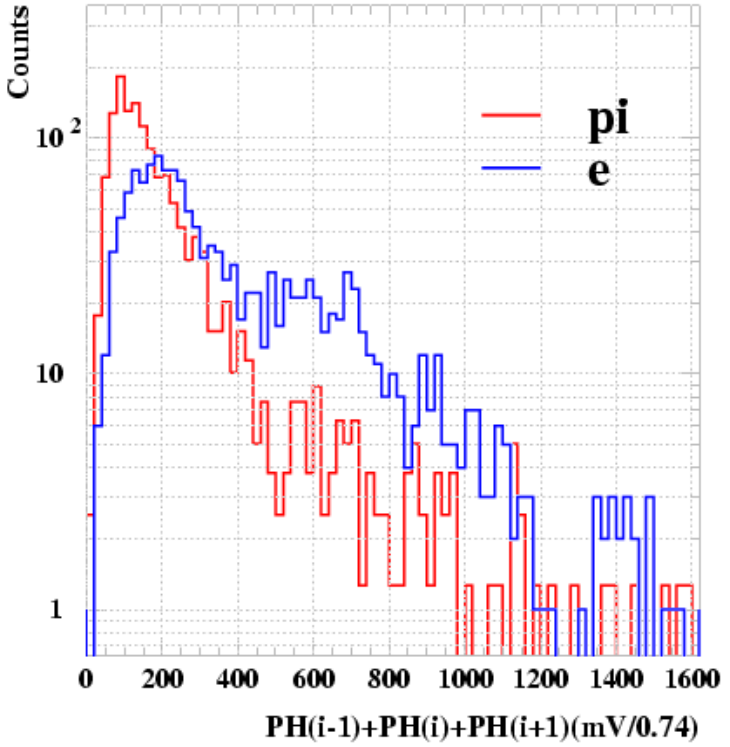






e/π Discrimination





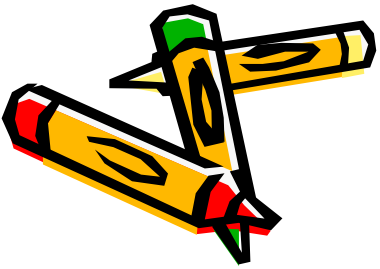
Simulations (TSR CBM Experiment):

1% pions efficiency needs 9 – 12 TRD layers (built from such a MWPC)

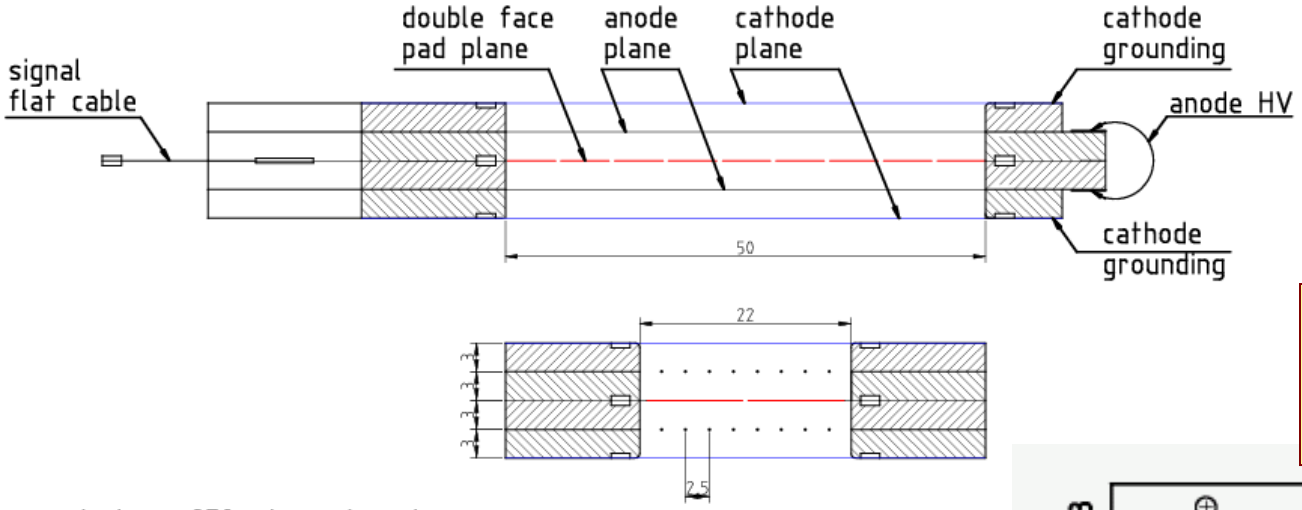
High Efficiency TRD for High Rate Environment

- ***Goal:*** ***to increase the conversion efficiency of the TR in one layer conserving the rate performance of the first prototype and the number of the readout channels.***

- ***Solution***: ***two identical MWPC with the same readout electrode between them built as a double sided pad-plane electrode.***



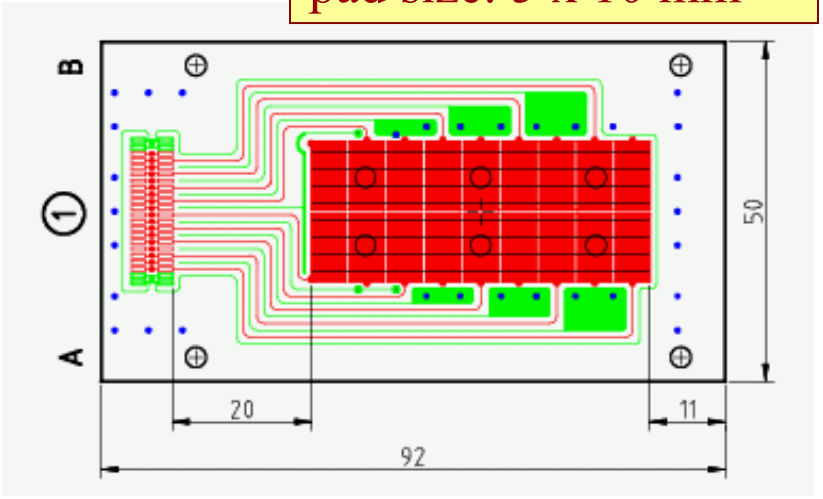
Double - sided pad readout HCRTRD prototype



-pad plane: 250 miu pc board;
-anode plane: 20 miu Wo+Au wire;
-cathode plane:Alu covered 25 miu
Kapton foil;
-frames: 3 mm thick pc board

Readout electrode

pad size: 5 x 10 mm^2



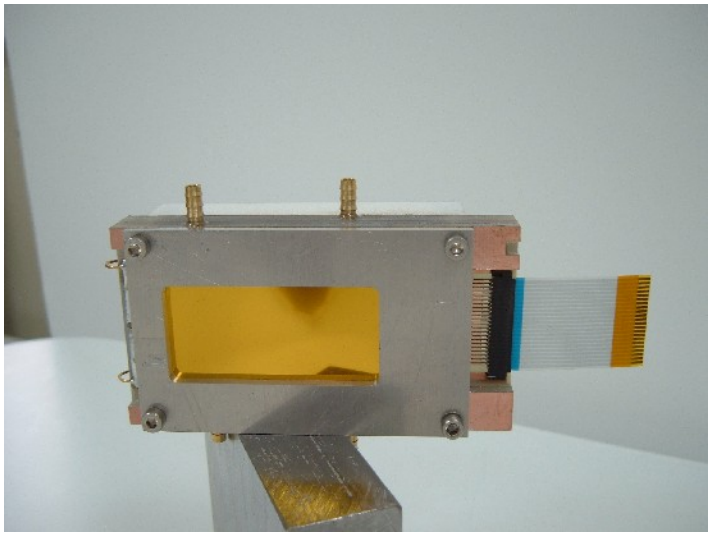
Three versions of such a prototype have been built:

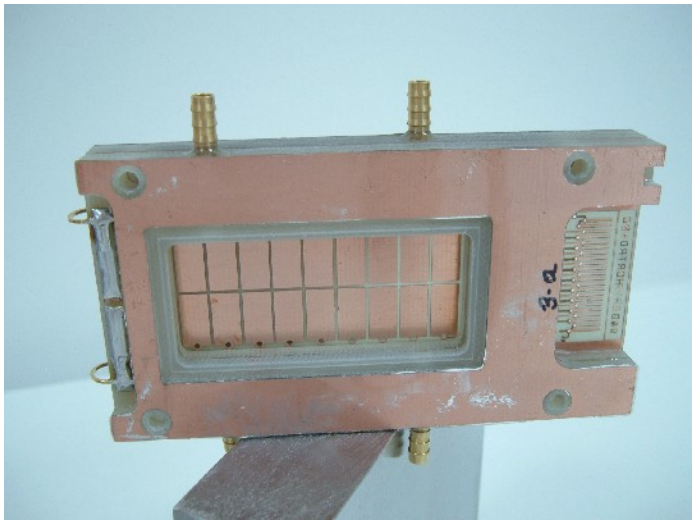
- ***The first:*** *the double – sided pad readout electrode has been made from PCB of 250 μm thickness; (TRD Present & Future Workshop, Cheile Gradistei, 24 - 28 September 2005)*

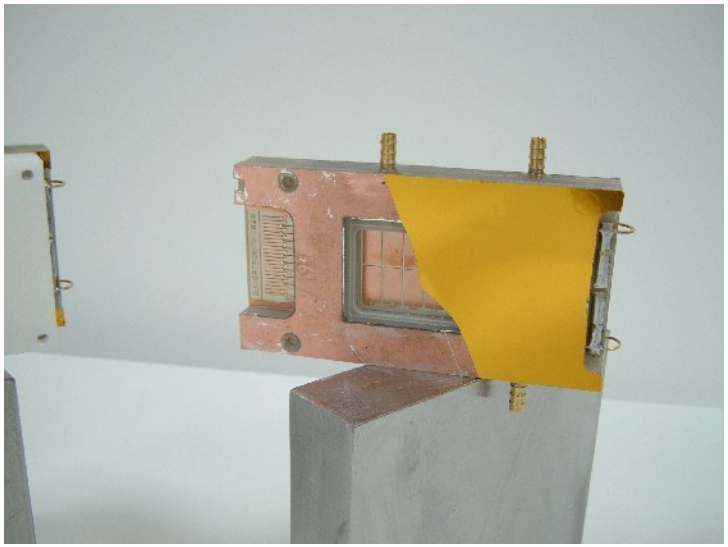
- ***The second:*** *the double – sided pad readout electrode has been obtained by etching the pad structure on a double sided kapton foil of 25 μm, covered with copper - collaboration with Münster University;*

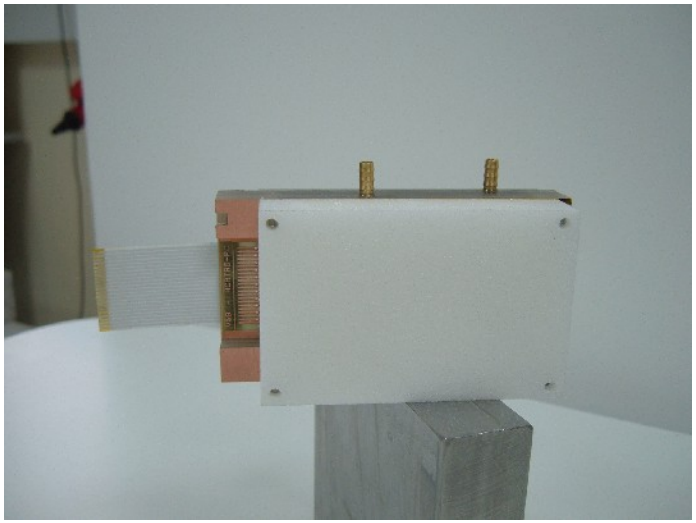
- ***The third:*** *the single – pad readout electrode has been made from mylar foil of 3 μm thickness, aluminized on both sides.*

First version - PCB Readout Electrode



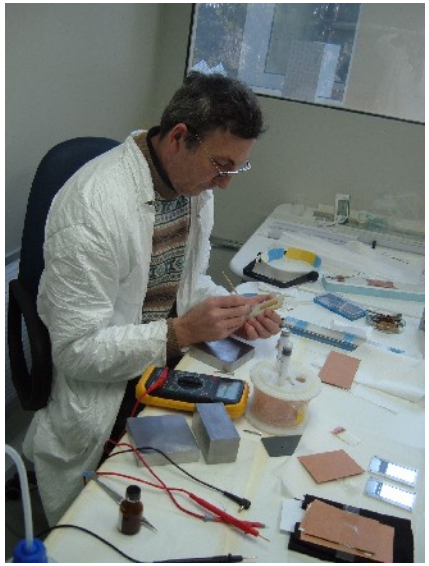


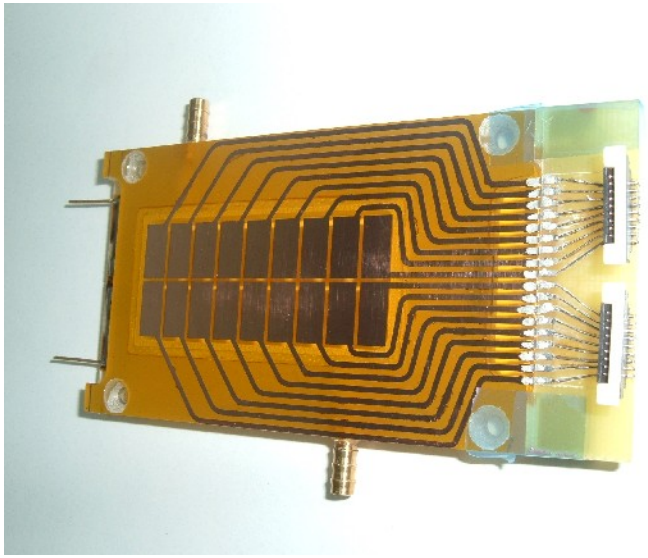




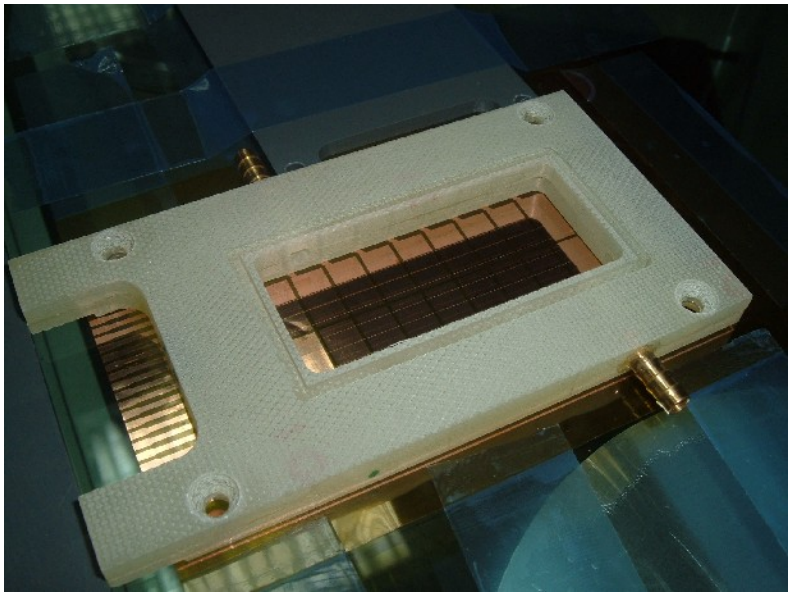
Second version - 25 μm Double - Sided Pad – Plane Electrode

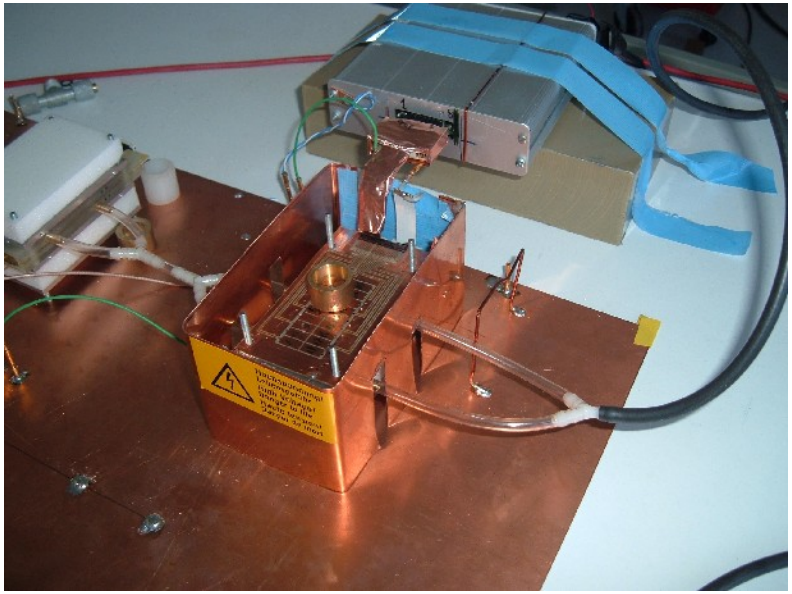
Collaboration with Münster University

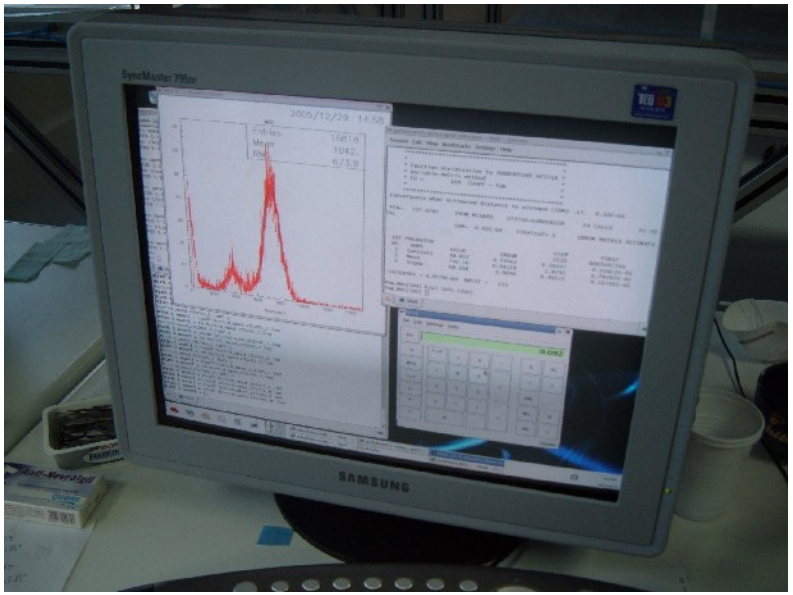




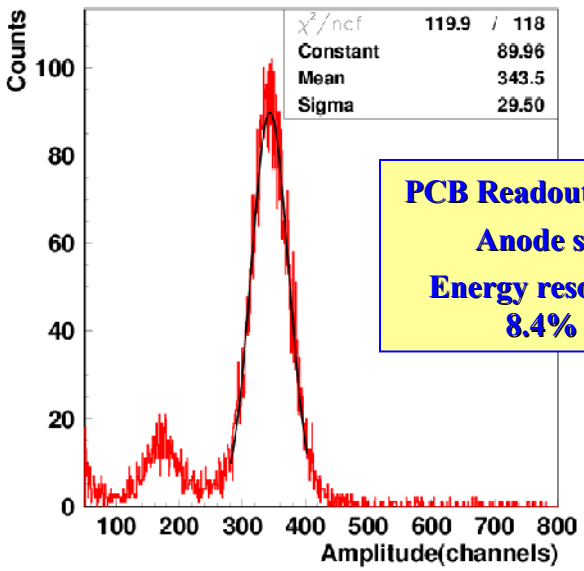
^{55}Fe Source Tests



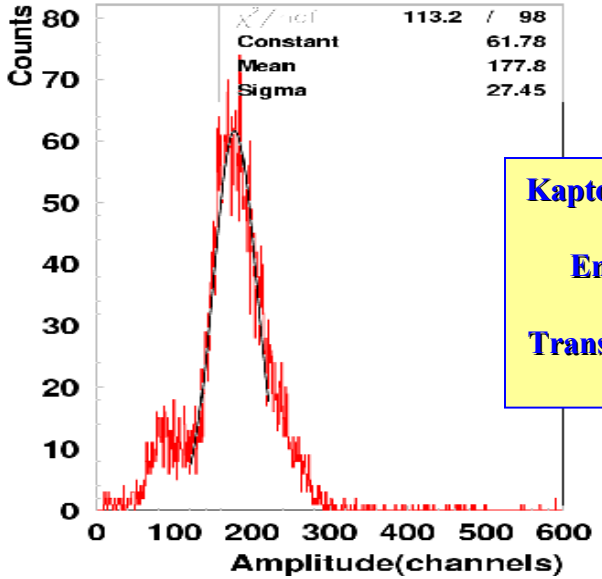




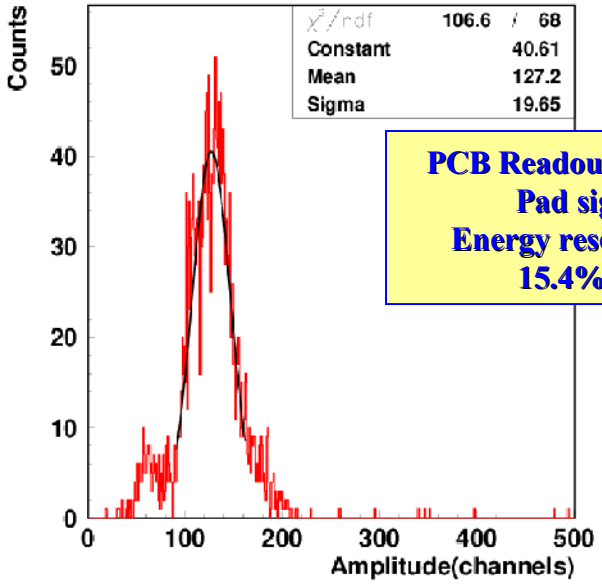
Results of the ^{55}Fe source tests



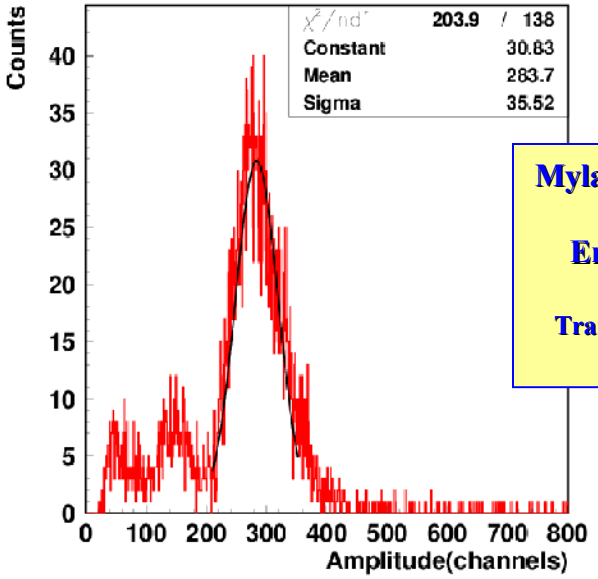
PCB Readout electrode
Anode signal
Energy resolution = 8.4% (σ)



Kapton Readout electrode
Pad signal
Energy resolution = 15.4% (σ)
Transmission of X – ray = 84 %

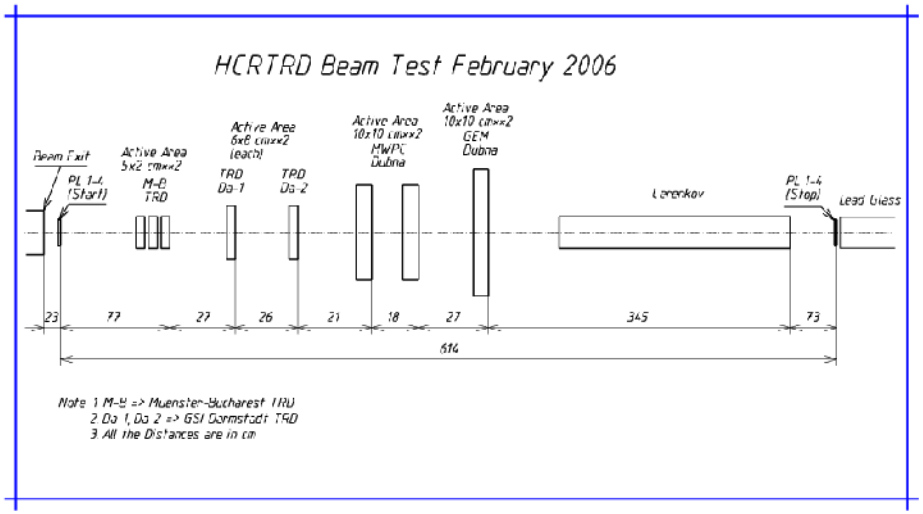


PCB Readout electrode
Pad signal
Energy resolution = 15.4% (σ)

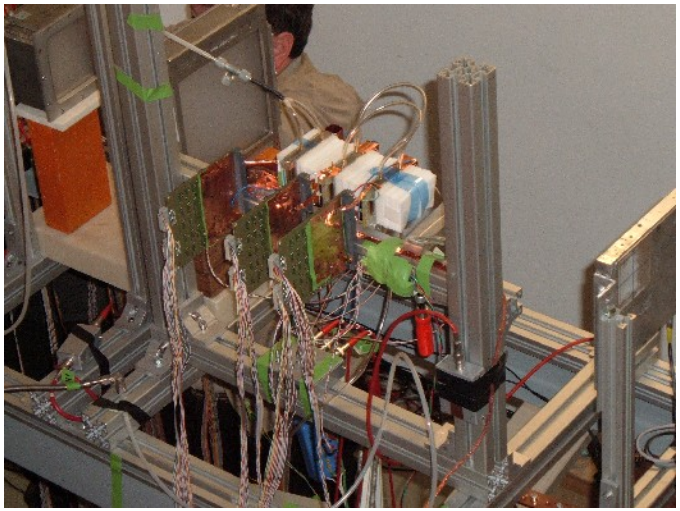


Mylar Readout electrode
Pad signal
Energy resolution = 12.5% (σ)
Transmission of X – ray = 98.5%

Beam test, February 2006
Experimental Setup

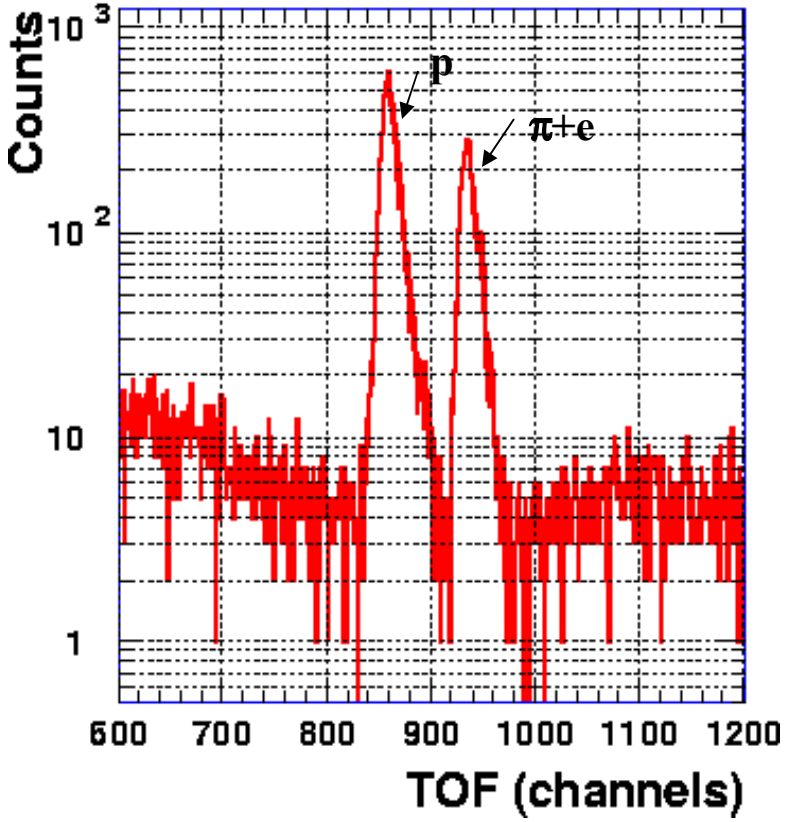


- 2 Scintillator arrays (ToF, trigger): each array - 4 scintillator paddles (4 x 1 x 0.5 cm^3 each)
- 2 Si - Strip Detectors (beam profile) for some runs;
- 3 MWPC - Bucharest (18 pads with total area of ~ 22 x 50 cm2)
- 2 MWPC - GSI (32 pads with total area of ~ 56 x 64 cm2)
- 2 MWPC - Dubna (active area 40 x 40 cm2)
- 1 GEM – Dubna (active area 10 x 10 cm2)
- Cherenkov detector + Pb-glass calorimeter
- FADC readout ; DAQ (MBS)

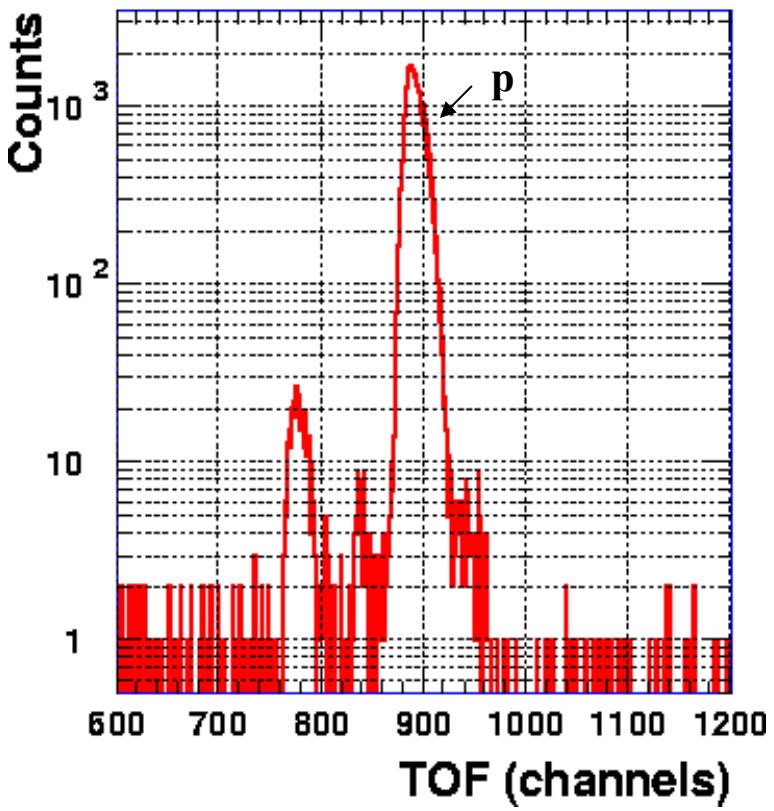


TOF spectra

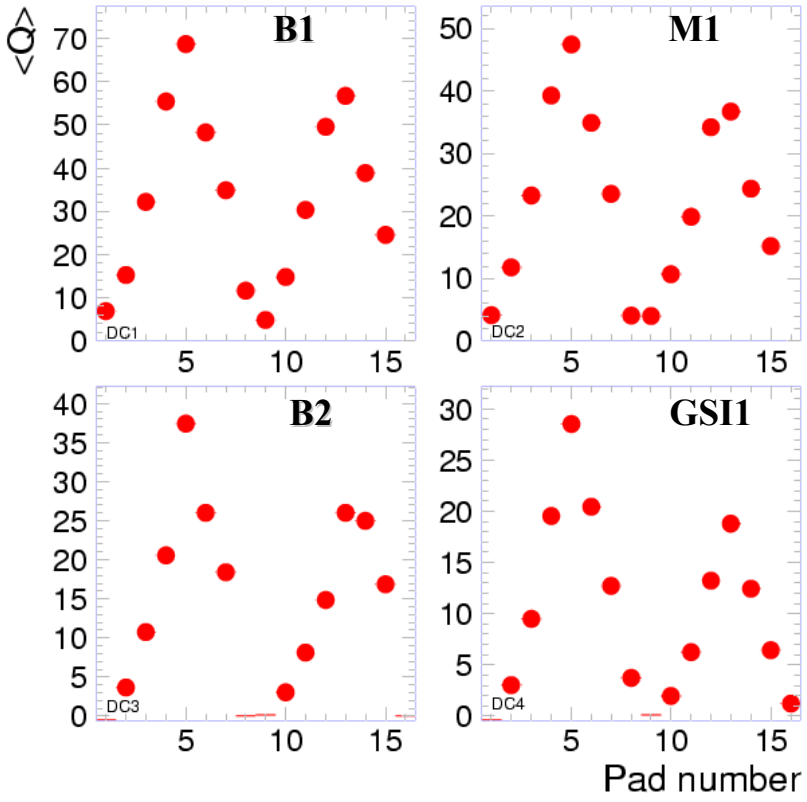
1.5 GeV/c

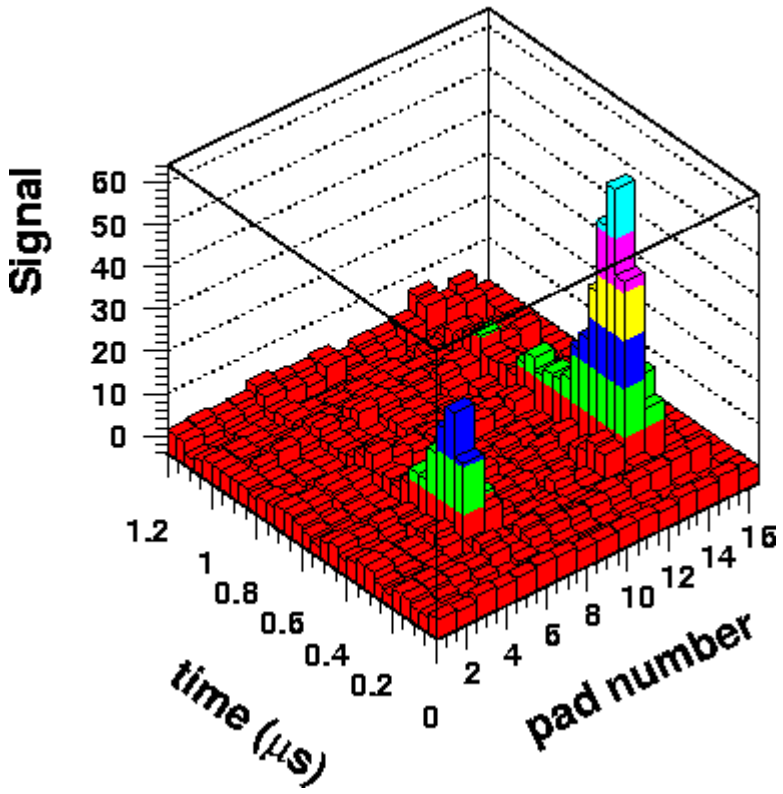


2 GeV/c



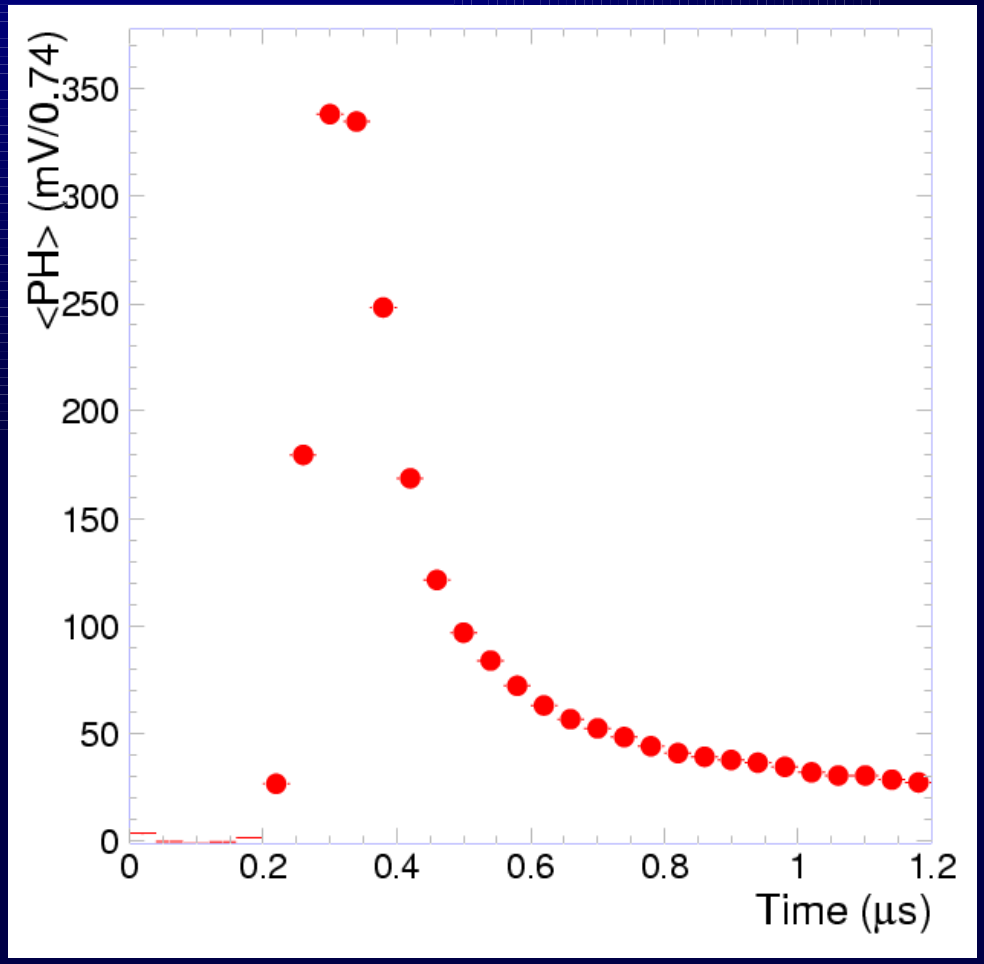
Average Charge Distribution on pads





For each tested detector were readout 16 pads

Pulse Height as a function of time bin



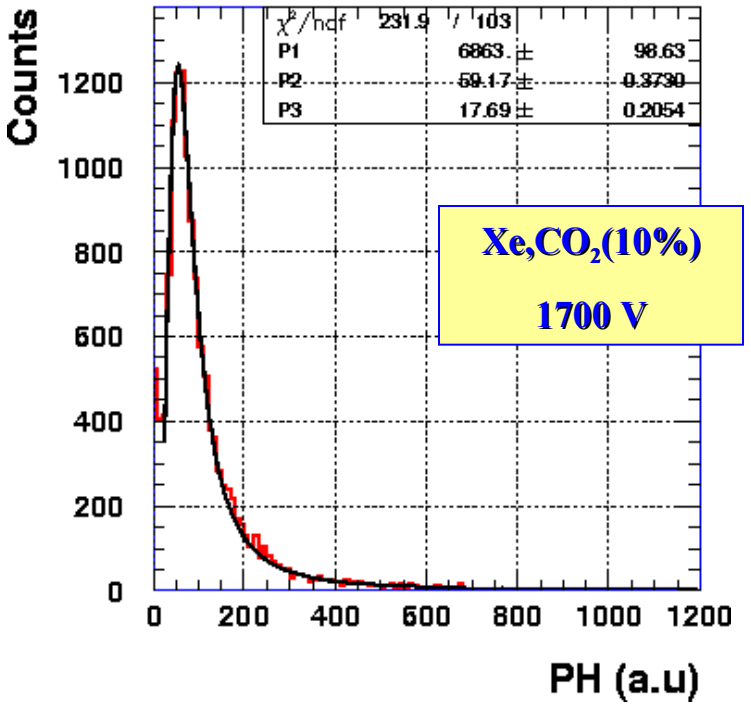
The energy deposit spectra were produced by two methods:

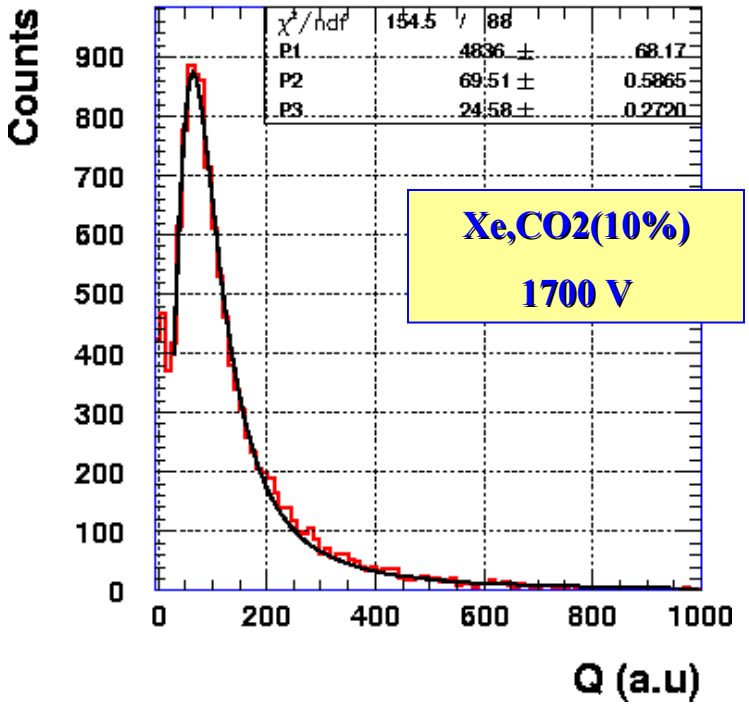
i) Taking the maximum pulse height

ii) Integrating the pulses over a gate of 1 μs, starting at 0.2 μs;

In both cases a sum over six pads was performed to obtain the total deposited charge.

Pulse Height and Charge Spectra





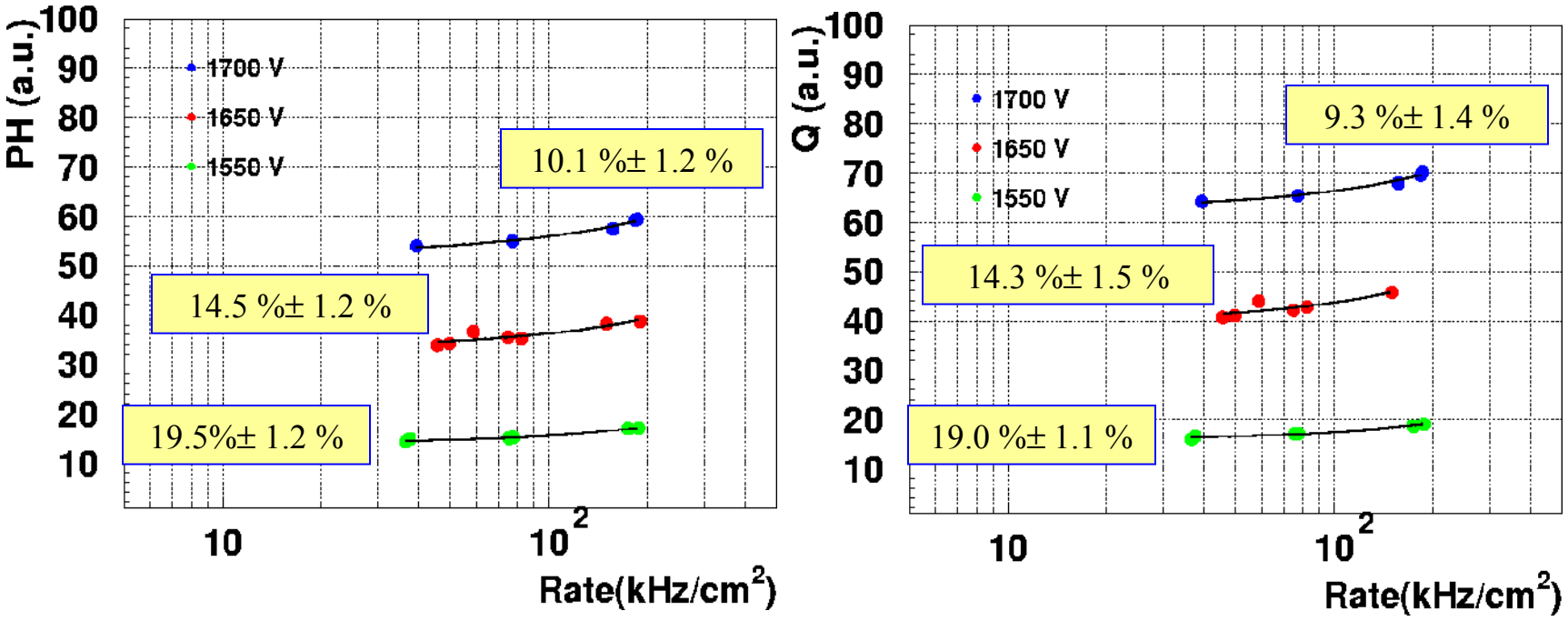
Describe data with Landau Function

Spectra are characterized by

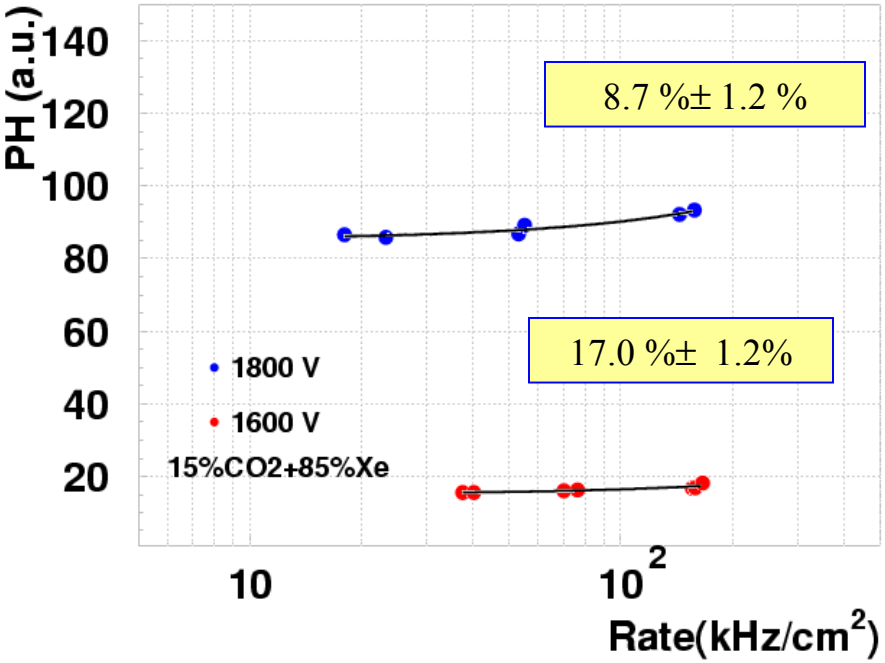
Most Probable Value

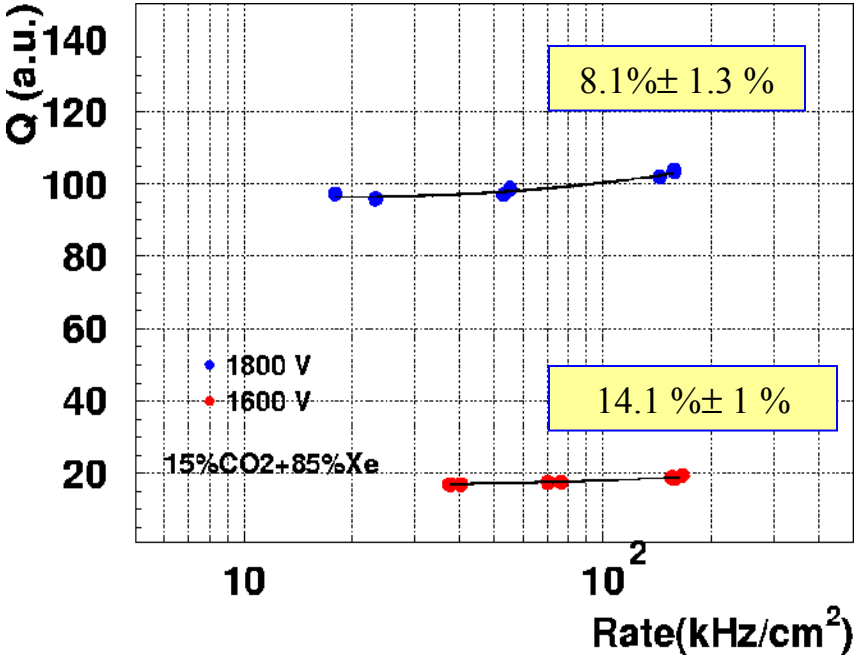
Width

High Counting Rate Effect
Xe,CO_2(10%), p=2 GeV/c

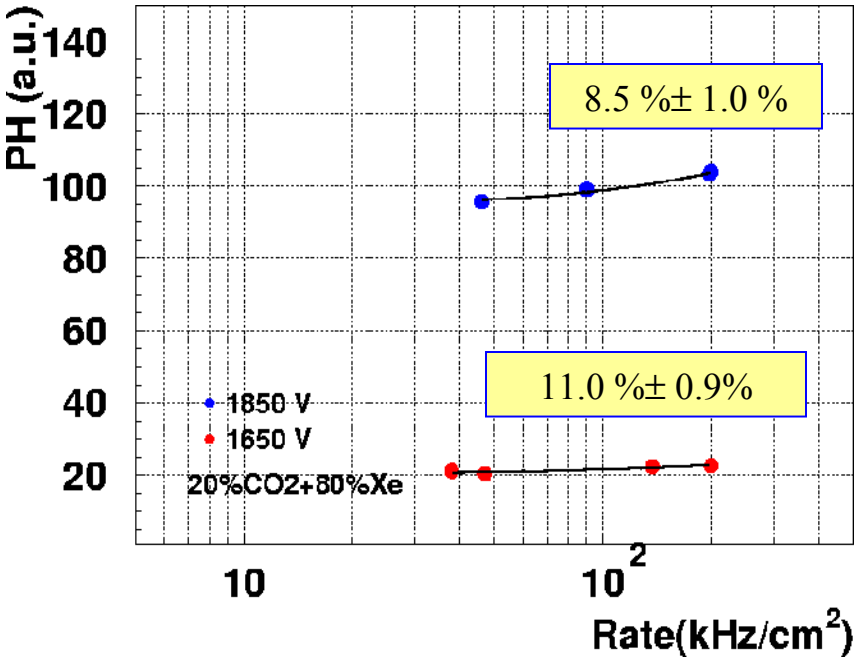


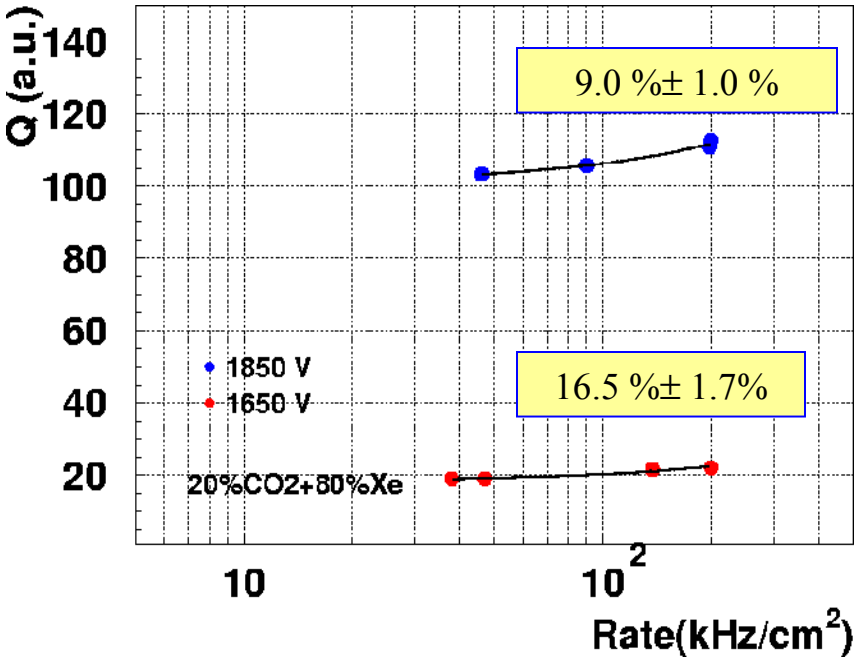
High Counting Rate Effect
Xe,CO_2(15%), p=2 GeV/c



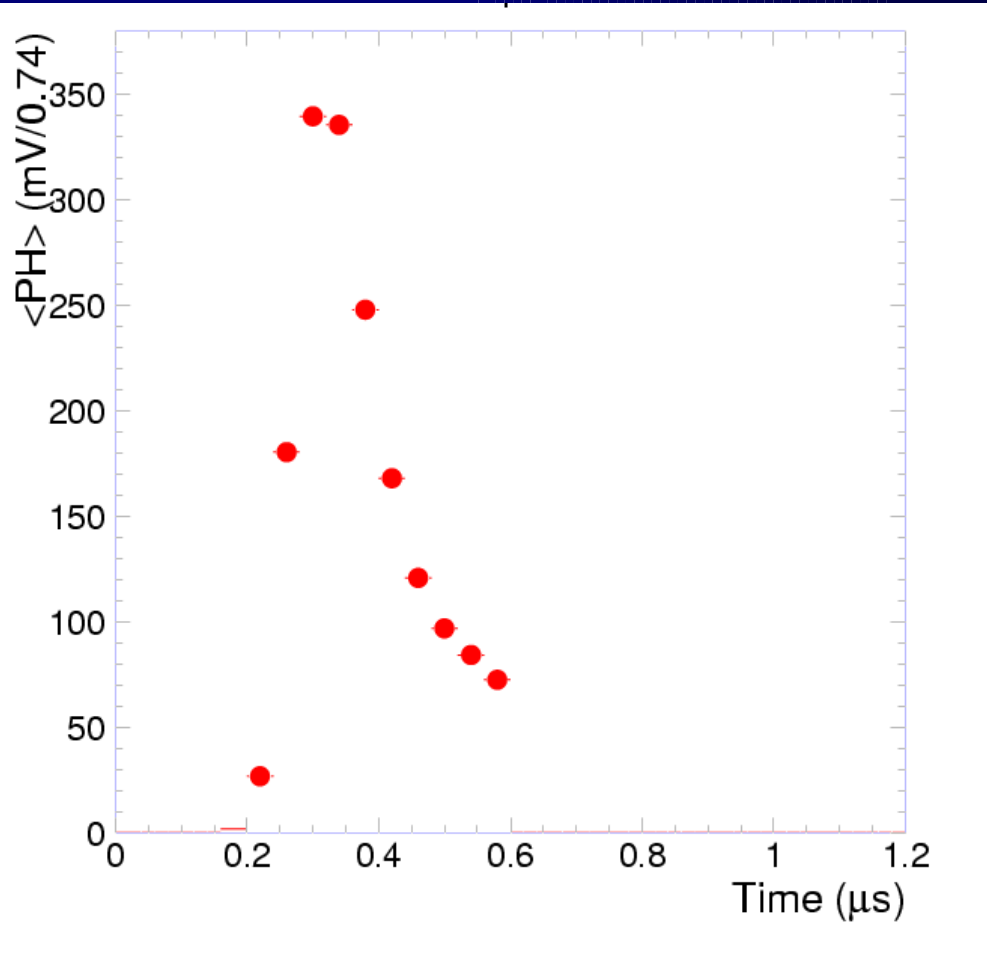


High Counting Rate Effect
Xe,CO_2(20%), p=2 GeV/c





Pulse Height as a function of time bin (5 – 15 bins)



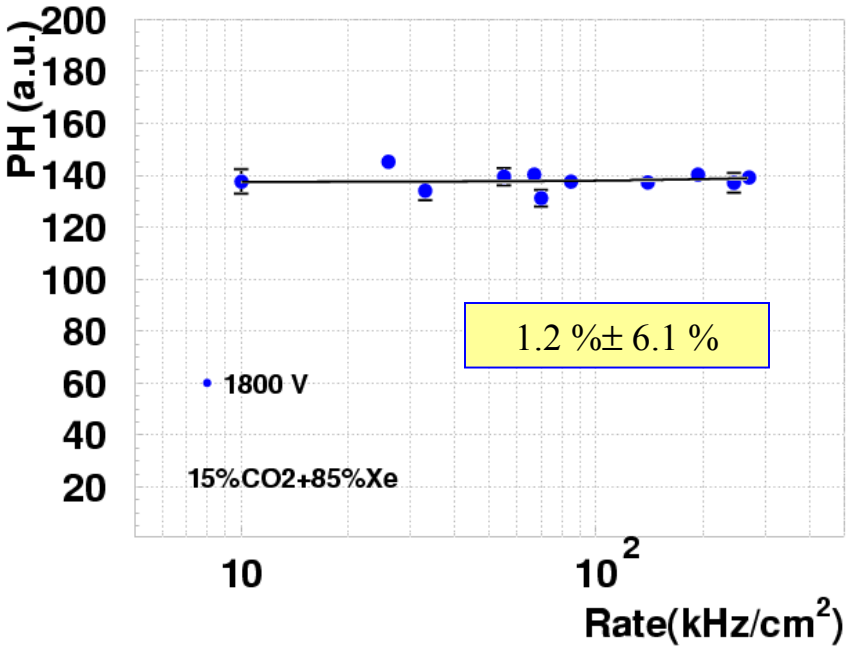
The energy deposit spectra were produced :

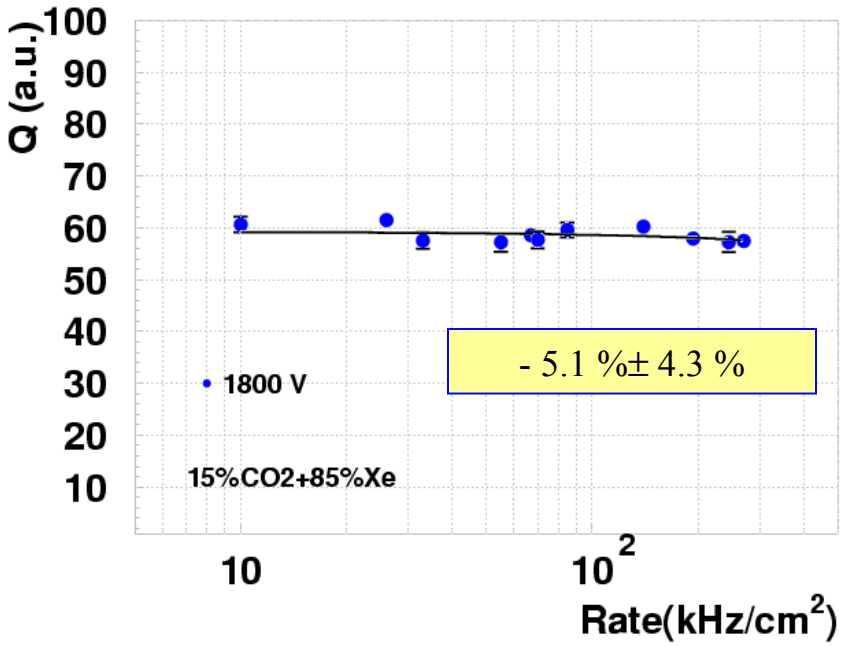
i) Taking the maximum pulse height

ii) Integrating the pulse

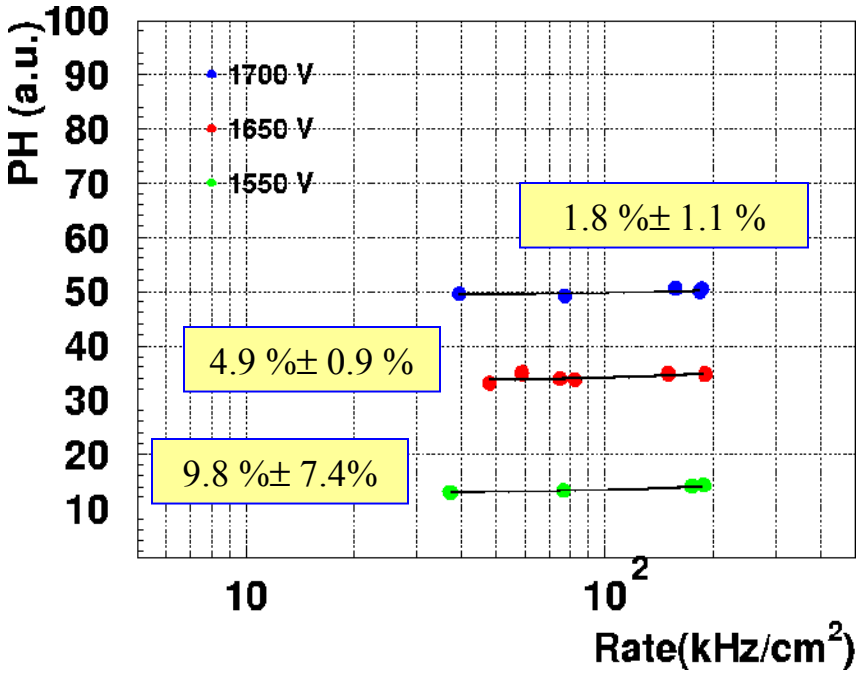
over a gate of 0.4 μs, starting at 0.2 μs;

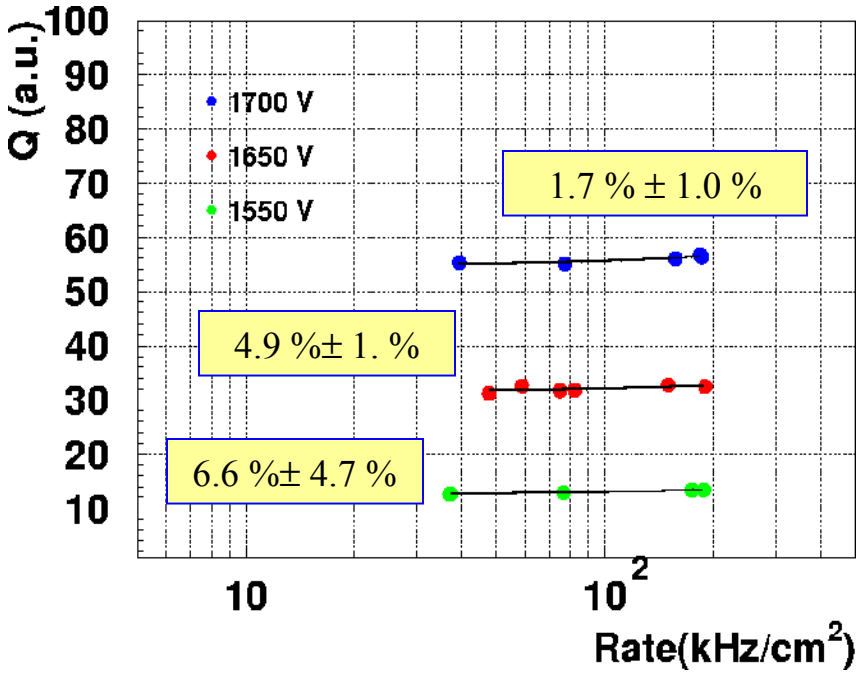
High Counting Rate Effect
Xe,CO_2(15%), p=1.5 GeV/c



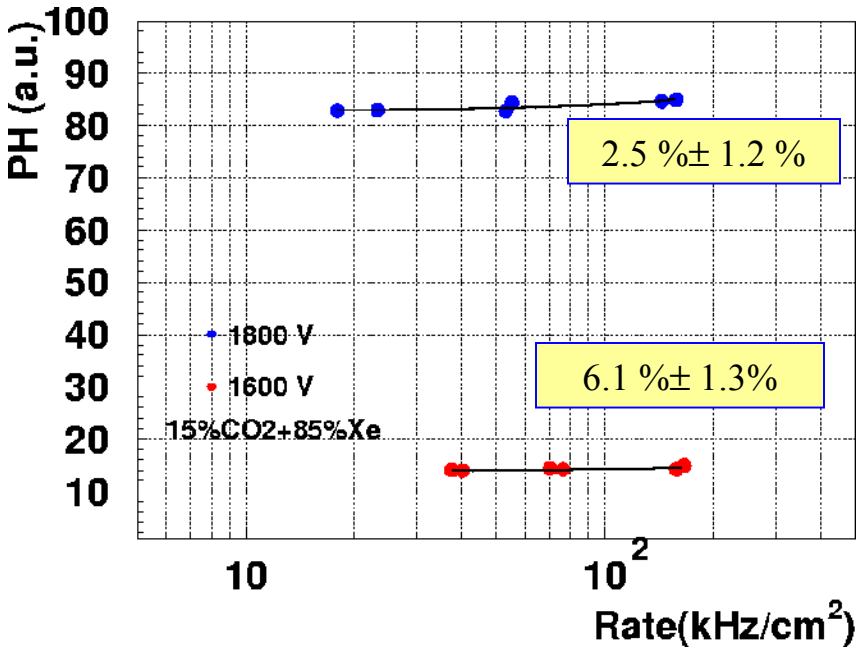


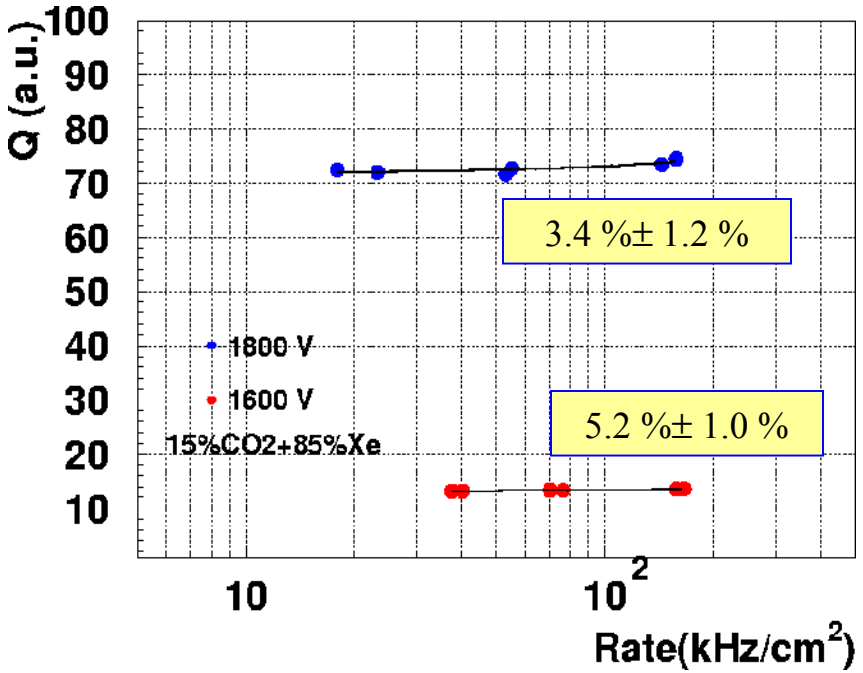
High Counting Rate Effect
Xe,CO_2(10%), p=2 GeV/c



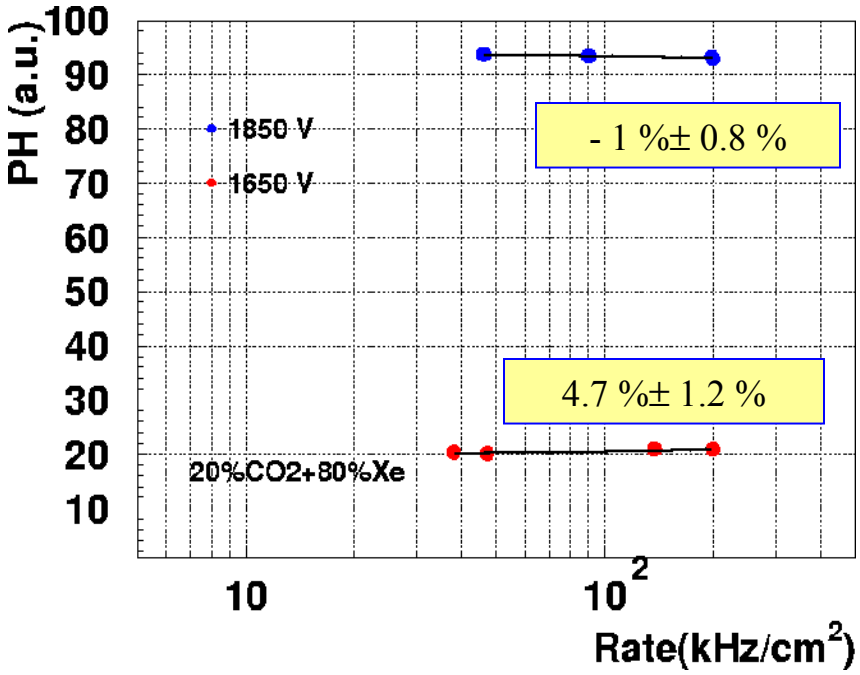


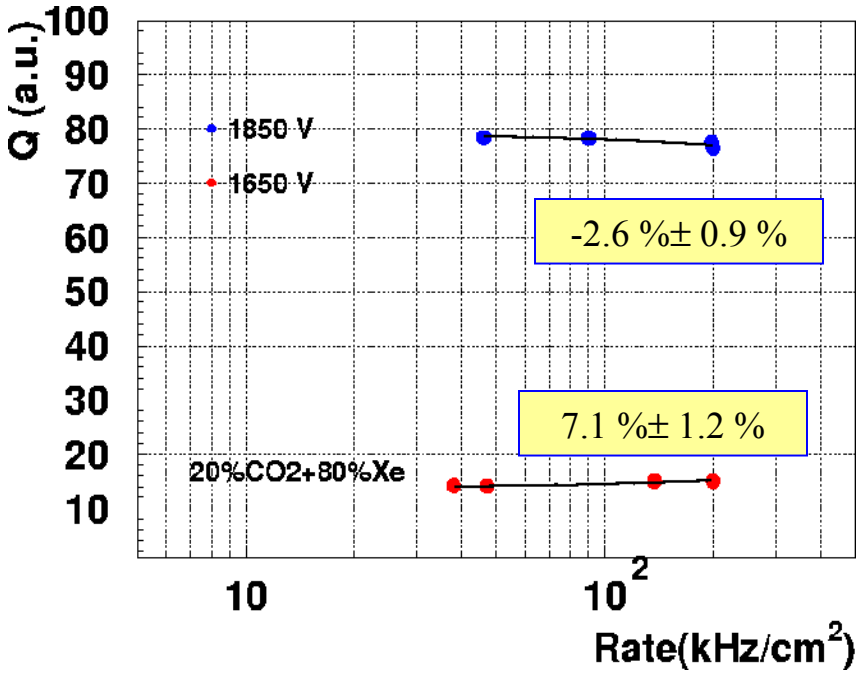
High Counting Rate Effect
Xe,CO_2(15%), p=2 GeV/c





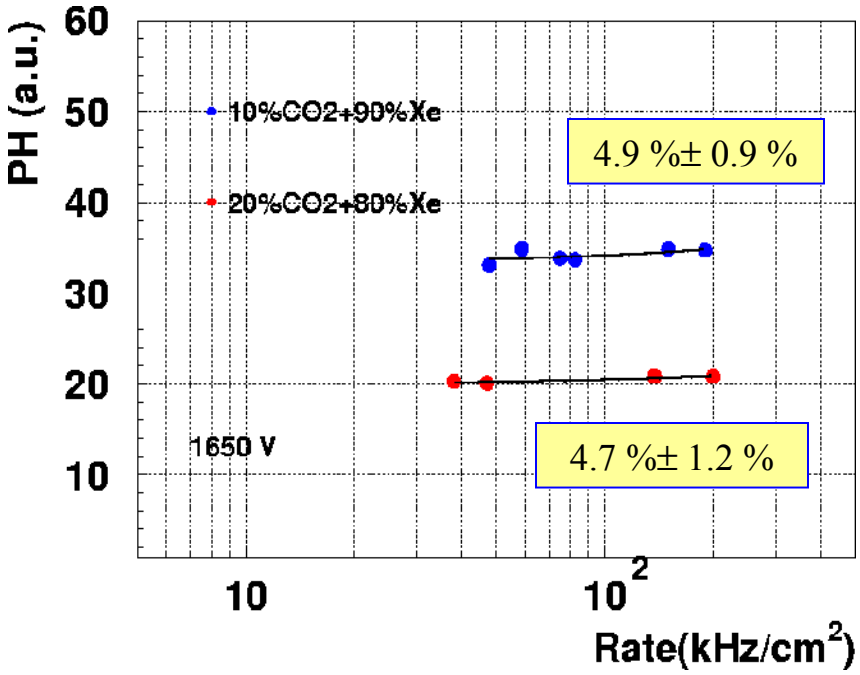
High Counting Rate Effect
Xe,CO_2(20%), p=2 GeV/c

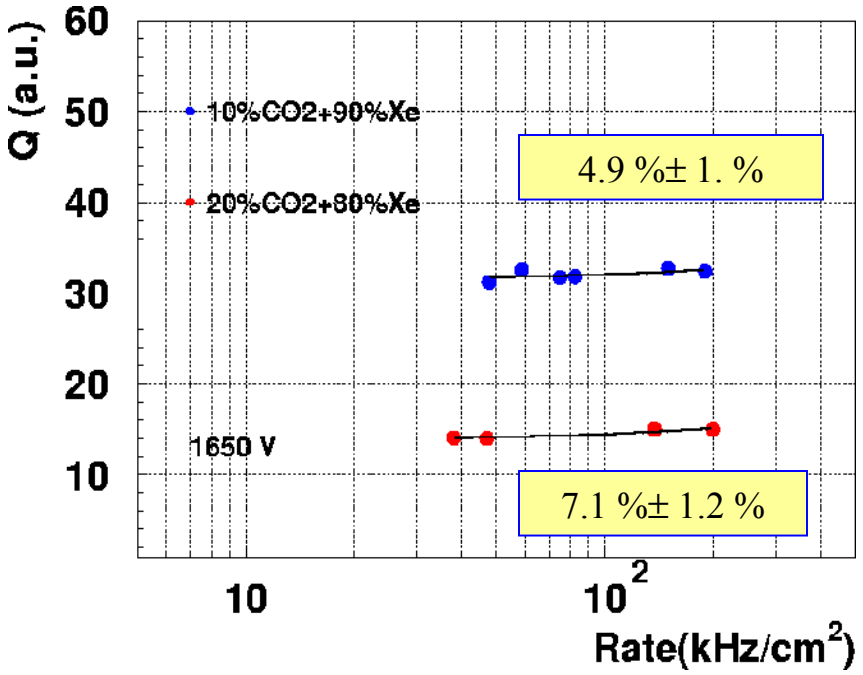




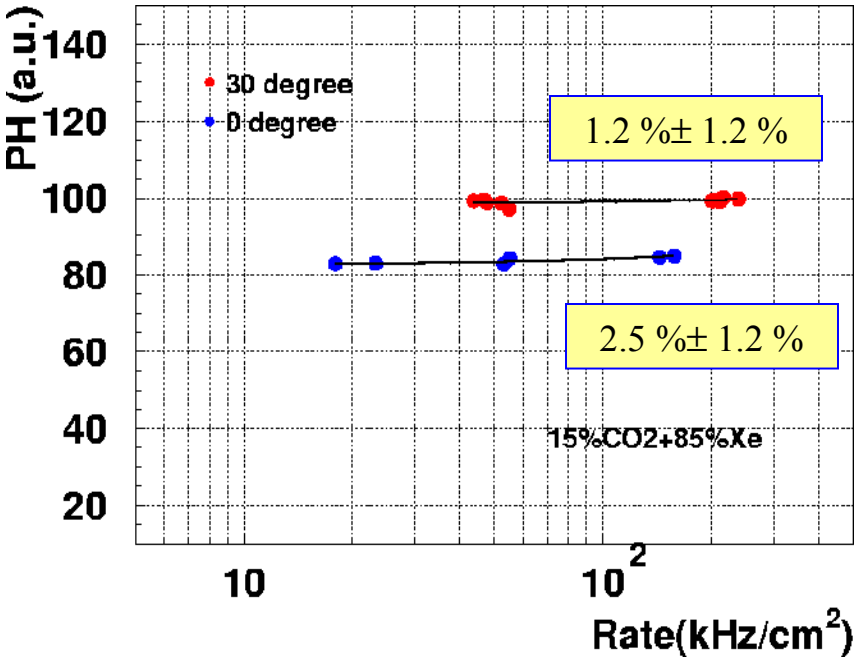
2 GeV/c, U=1650 V,

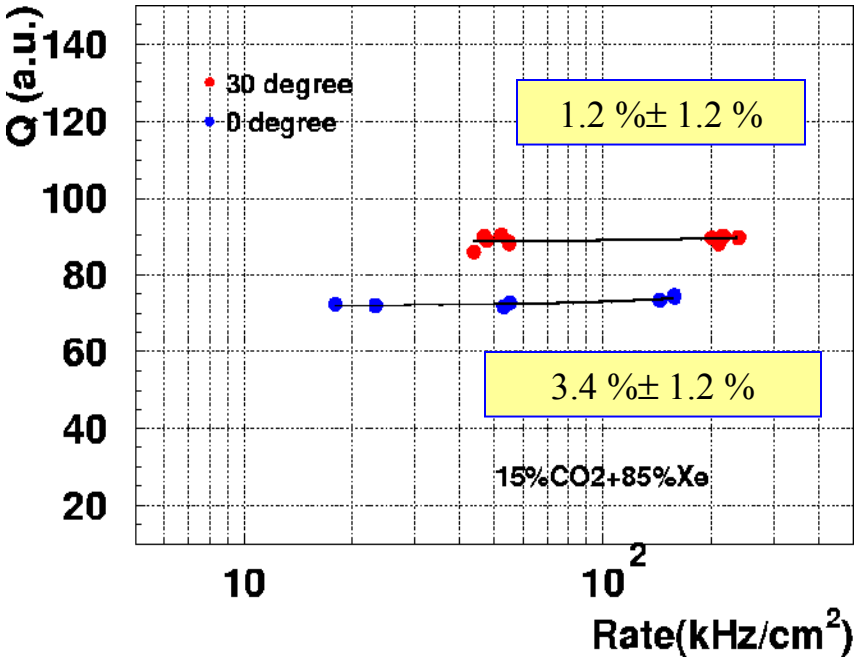
Xe,CO_2(10%), Xe,CO_2(20%)



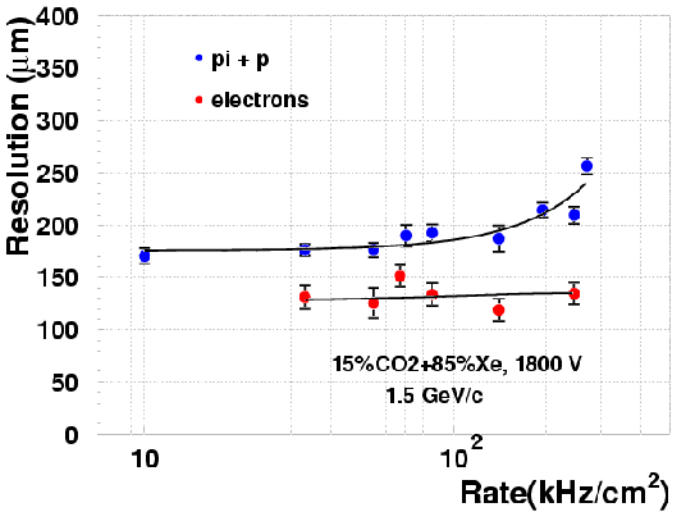


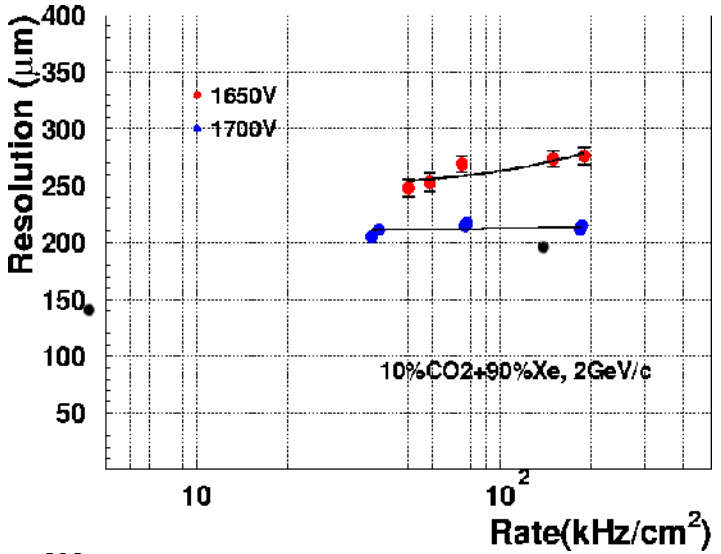
Rate Dependence for Tilted Chamber @ 30^0

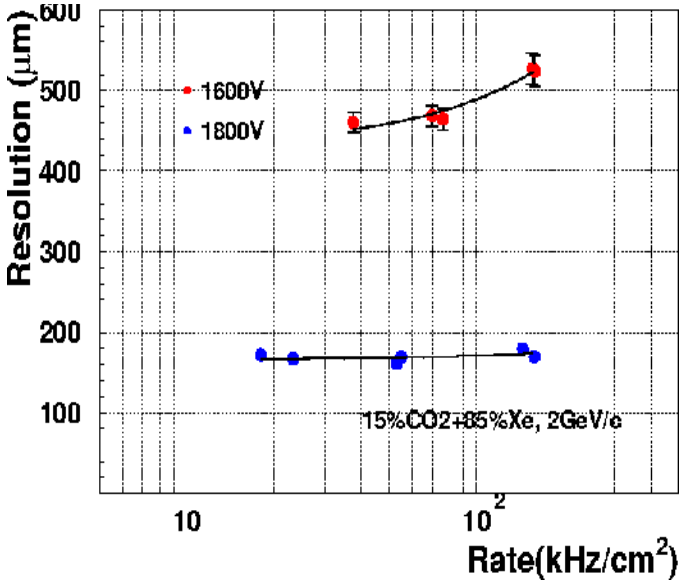


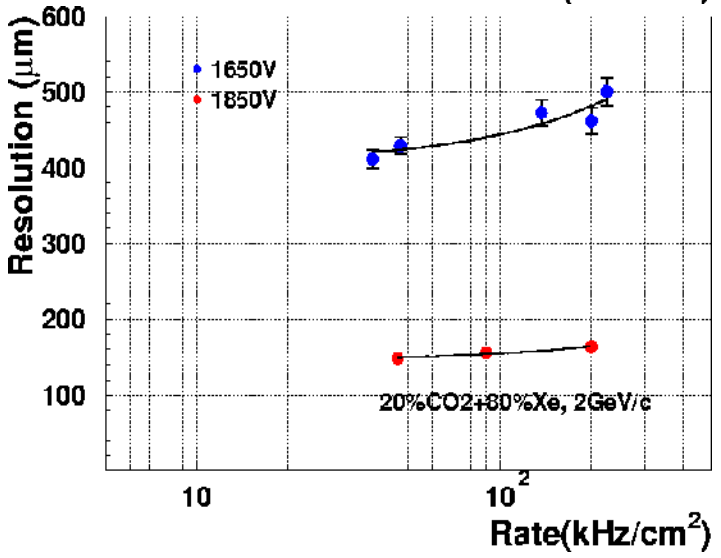


Rate Dependence of the Position Resolution

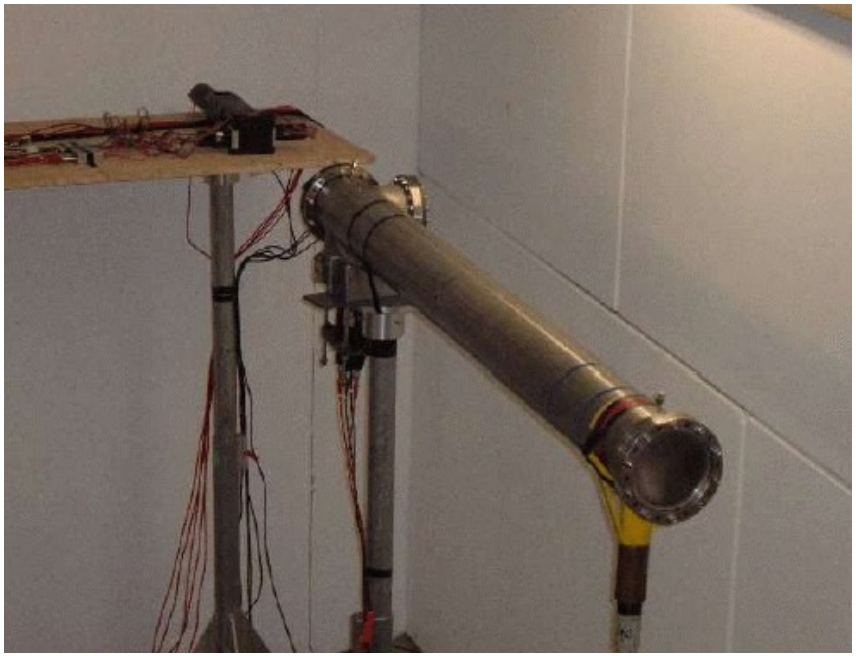


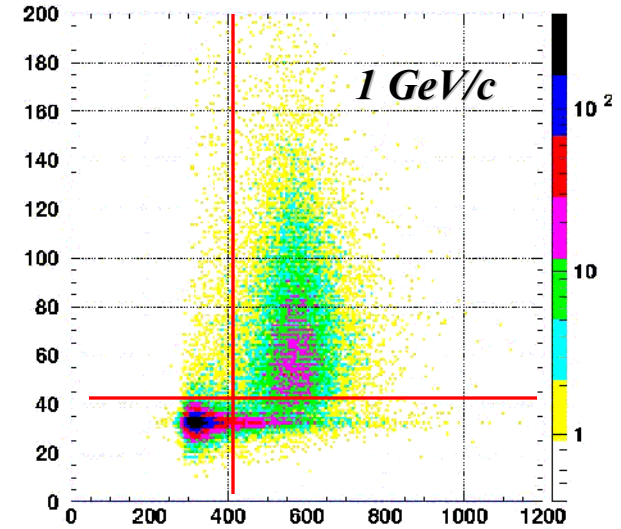


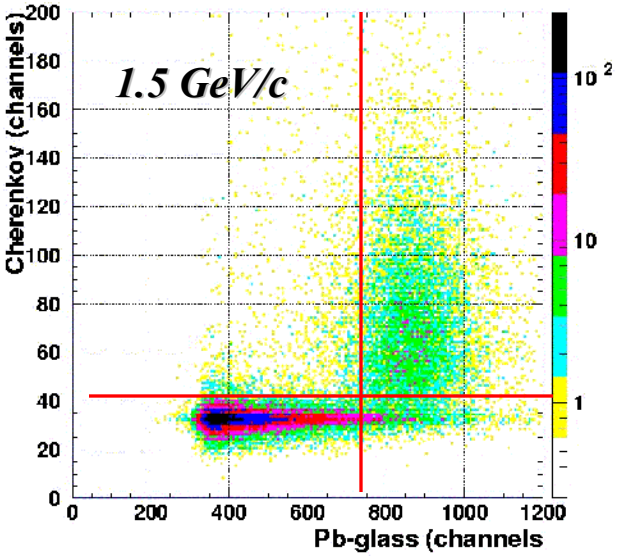




Electron Identification

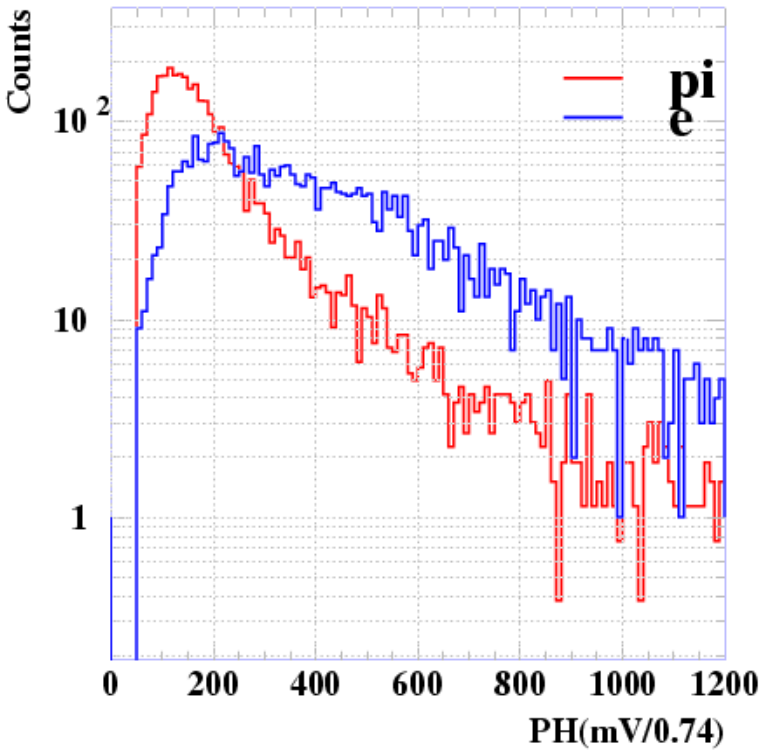




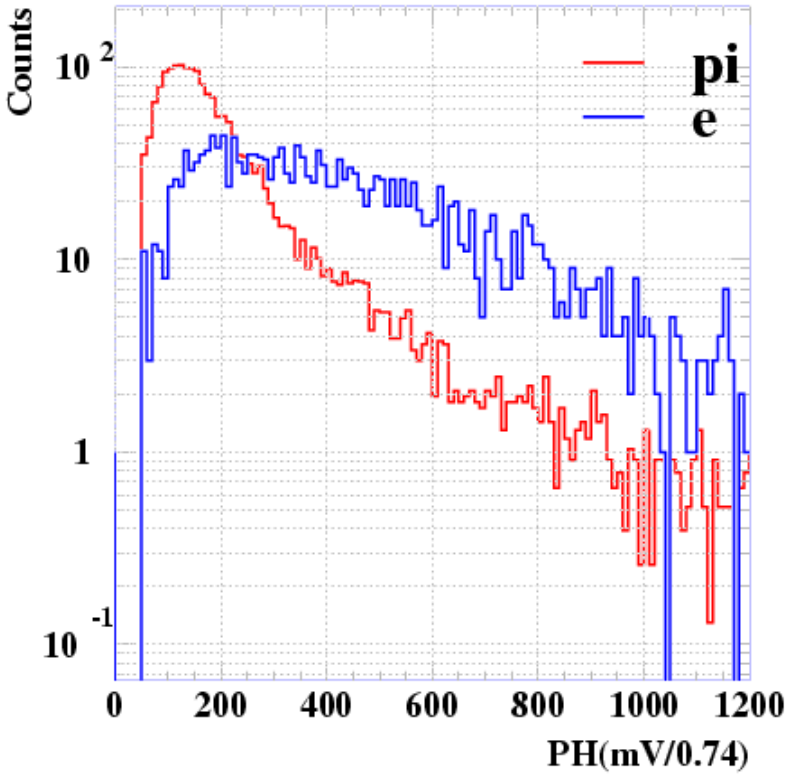


e/pi discrimination performance

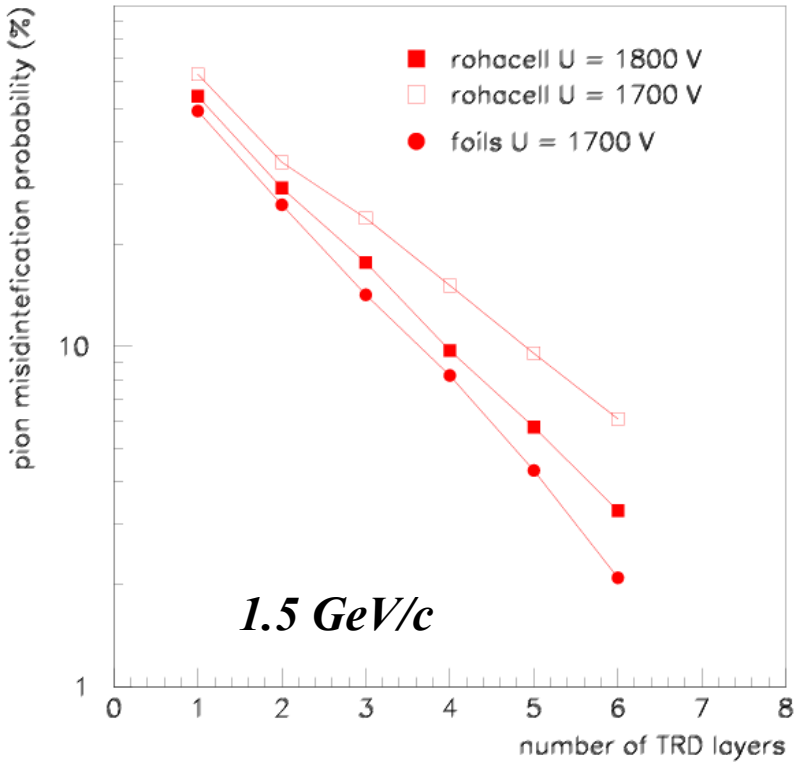
1 GeV/c



1.5 GeV/c



e/pi discrimination performance



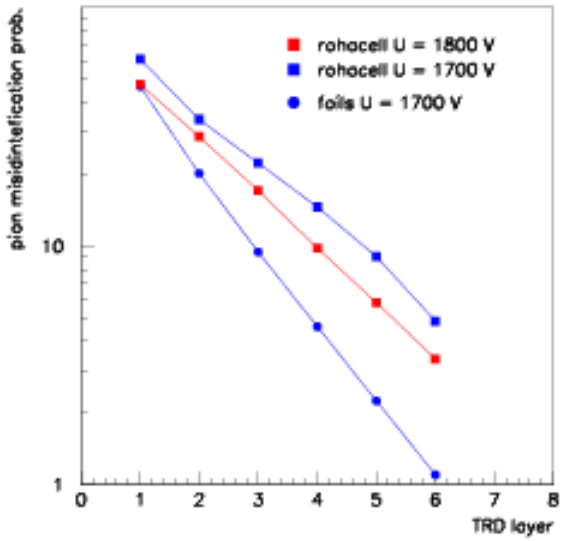
Pion eff @1700 V, rohacell = 6.12 %

Pion eff @1800 V, rohacell = 3.29 %

Pion eff @ 1800 V, foils = 1.12 %

Pion eff @1700 V, foils = 2.09 %

e/pi discrimination performance



Conclusions

- ***The new HCRTRD prototype could be a solution for the TRD subdetector of the CBM experiment; it satisfies the requirements in terms of signal deterioration, position resolution degradation and pion rejection factor with a reasonable number of readout channels;***

- ***We have a geometric concept to cover the small polar angles with layers built with from such prototypes; a polygon made from such Double MWPC strips;***

- ***This new prototype could be used, also, for muon detection, if the CBM Collaboration will decide that it is a better solution to identify the short – lived vector mesons by their $\mu^-\mu^+$ decay.***

Participants:

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PI-Heidelberg, Münster University

within I3HP/FP6 JRA 4 Project