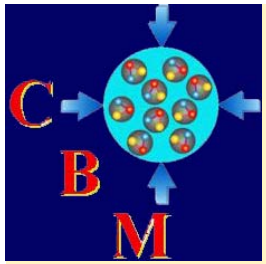
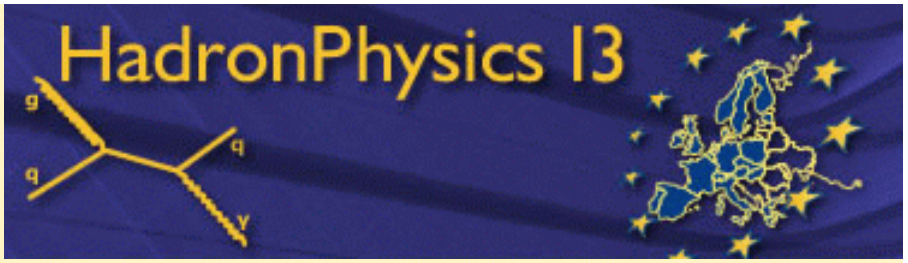




High Counting Rate Transition Radiation Detector

Mariana Petris, Mihai Petrovici, Victor Simion, Ionela Berceanu, Dorin Moisa

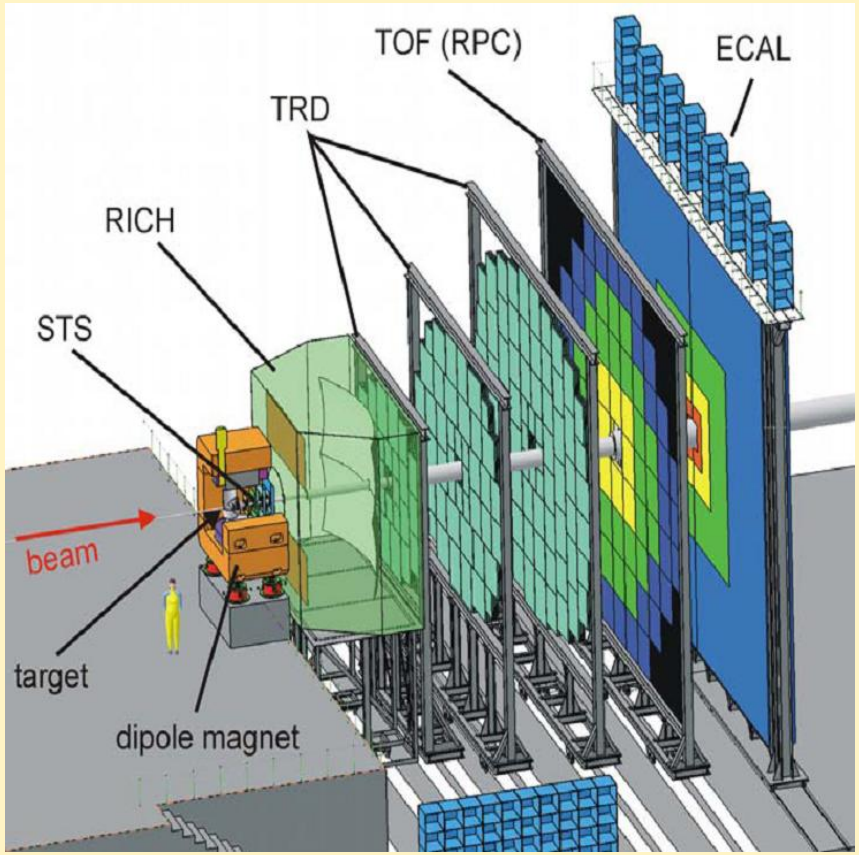
NIPNE, Bucharest

Outline

- ***TRD prototype for High Counting Rate Environment***
  - ***^{55}Fe source tests***
  - ***In beam tests:***
    - ***✓investigation of the rate capability***
      - ***pulse height and charge***
      - ***position resolution***
    - ***✓e/π discrimination***
- ***High Efficiency TRD prototype for High Counting Rate Environment***
  - ***^{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)**

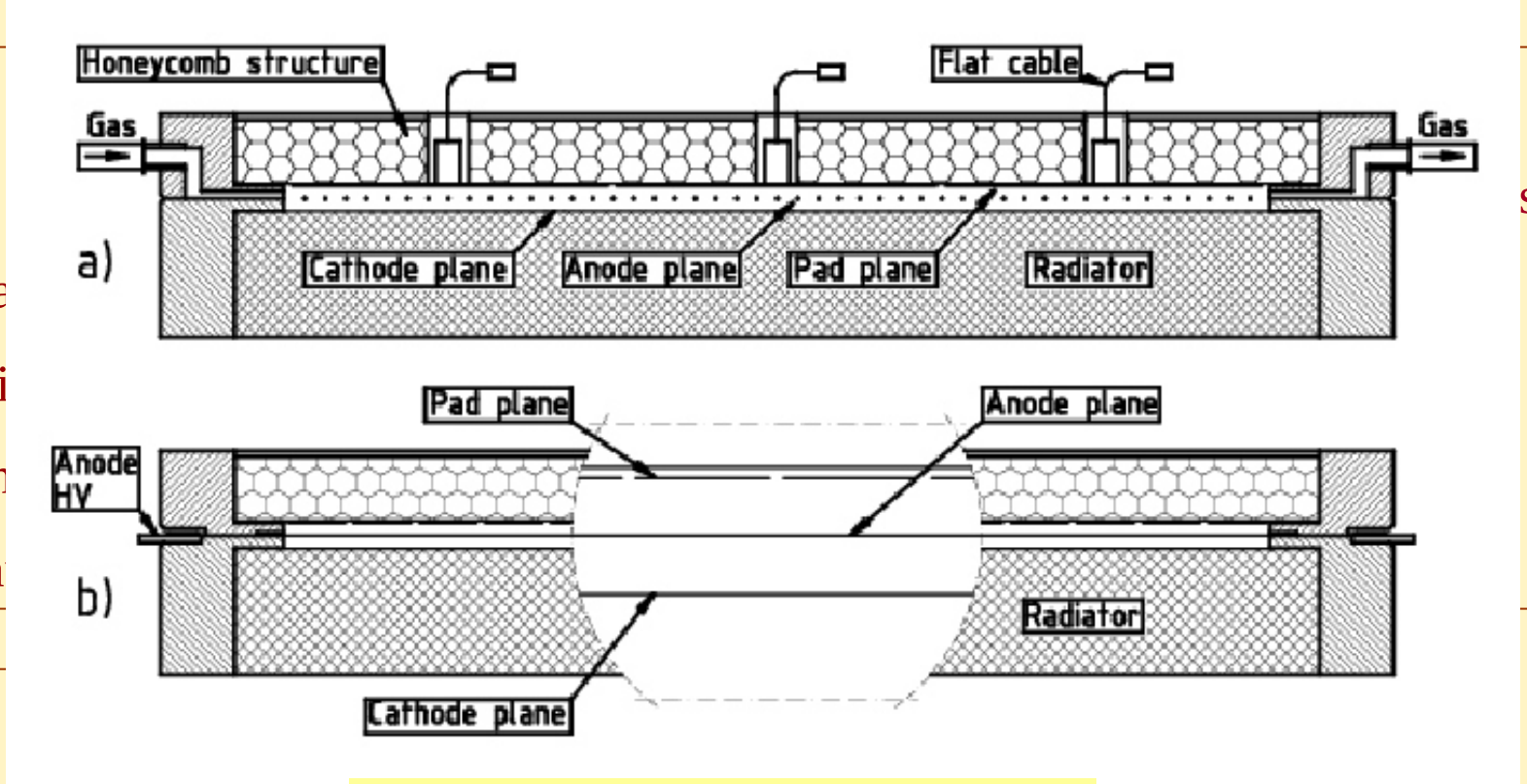
TRD subdetector – possible scenario:

- *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 10^5 part/cm^2·sec)*
- *Identification of high energy electrons (γ > 2000); pion rejection factor > 100*
- *Tracking of all charged particles: position resolution ~ 200 – 300 μm*

HCRTRD - prototype

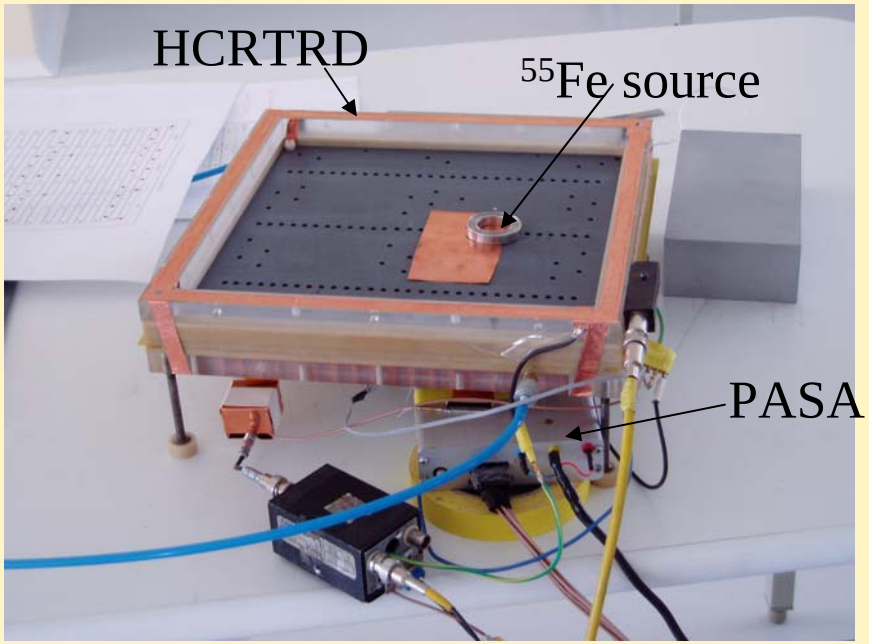
- type
- π_{rej} (a
- Maxi
- Coun
- Gran

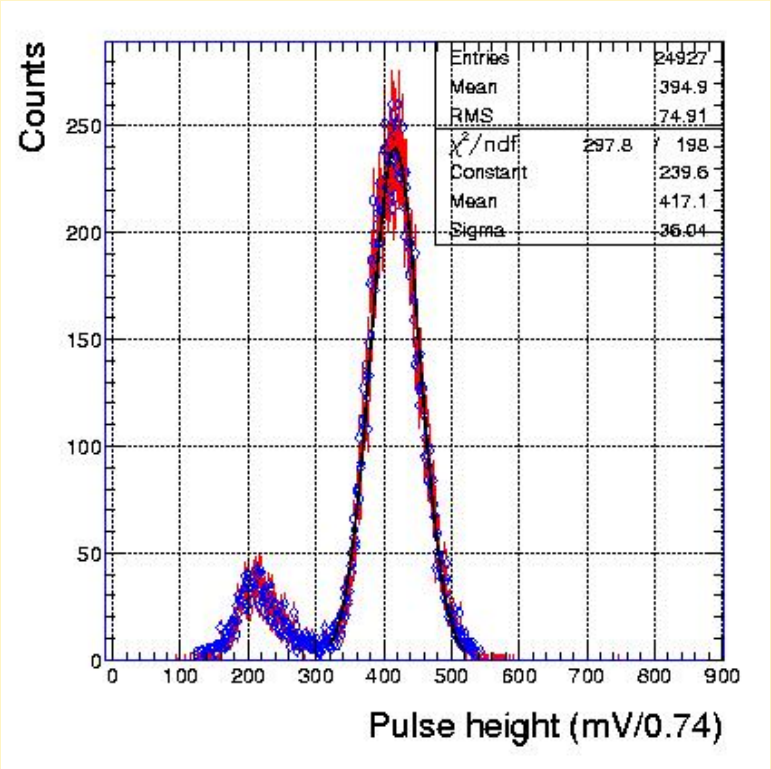
s)



- type: radiator + MWPC
- maximum drift time < 100 ns
cell size ~ 1·6 cm²
- anode pitch = 2.5 mm

^{55}Fe Source Tests





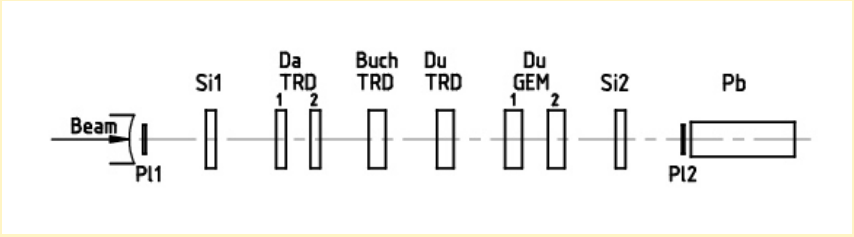
85% Ar + 15% CO_2 ; HV 1700 V;

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

Energy Resolution (pad signal): ~8.6 % (σ); ~20 % FWHM

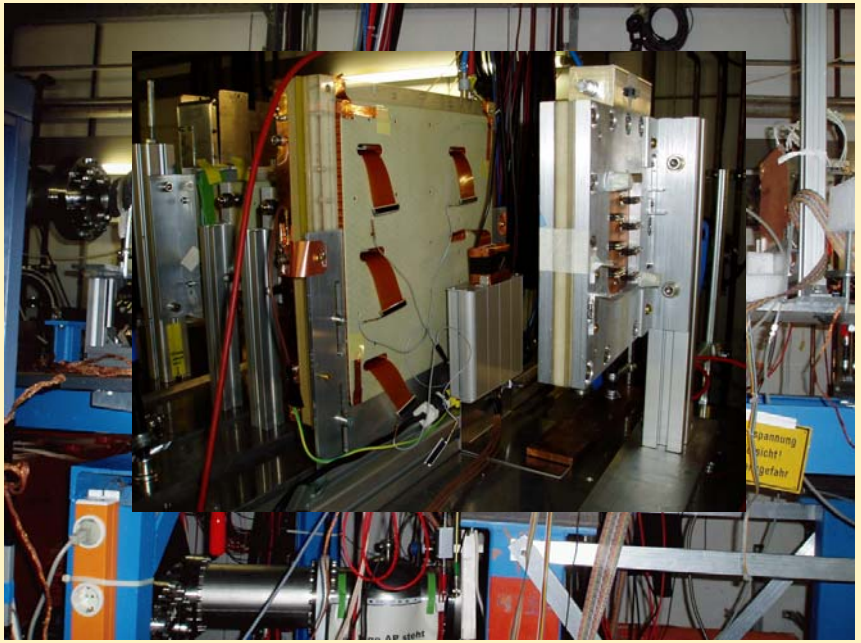
Beam Tests

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



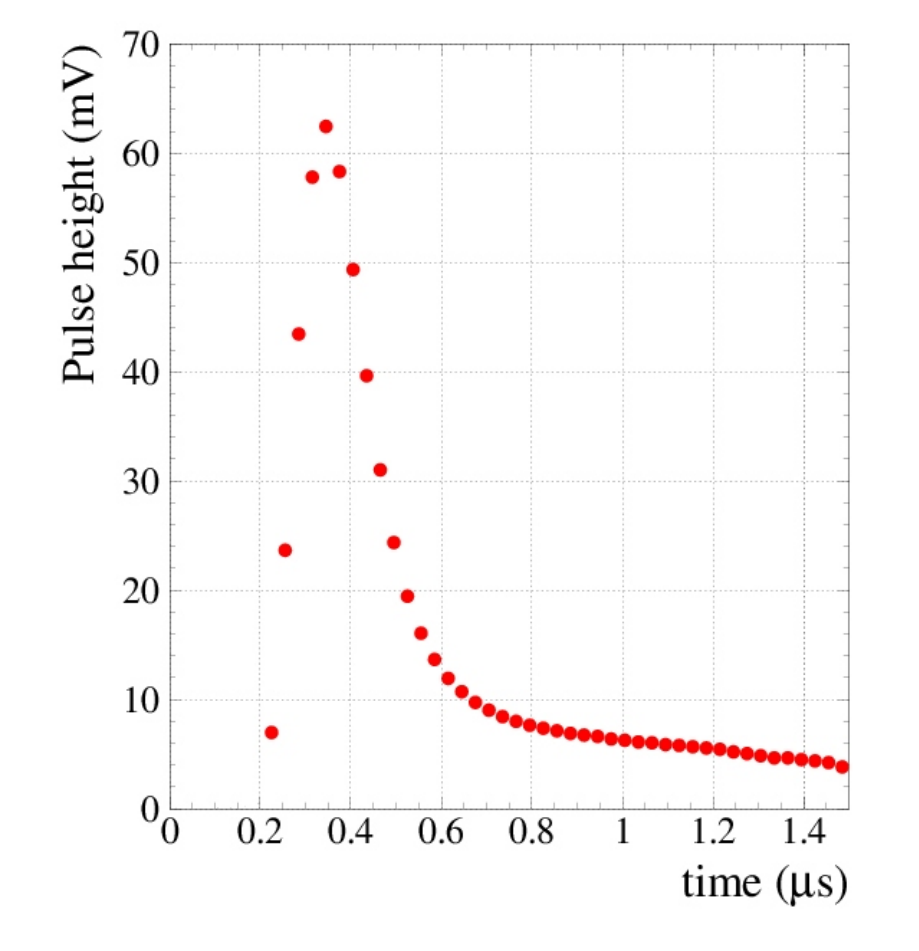
SIS, GSI - Darmstadt

Experimental Setup



- 2 Scintillators (ToF, trigger)
- 2 Si -Strip Detectors (beam profile definition)
  - 2 MWPC - GSI (10 x 10 cm^2)
  - 1 MWPC – NIPNE (24 x 24 cm^2)
  - 1 MWPC - JINR (10 x 10 cm^2)
  - 1 GEM – JINR
- Pb - glass calorimeter
- FADC readout ; DAQ (MBS)

Average signal



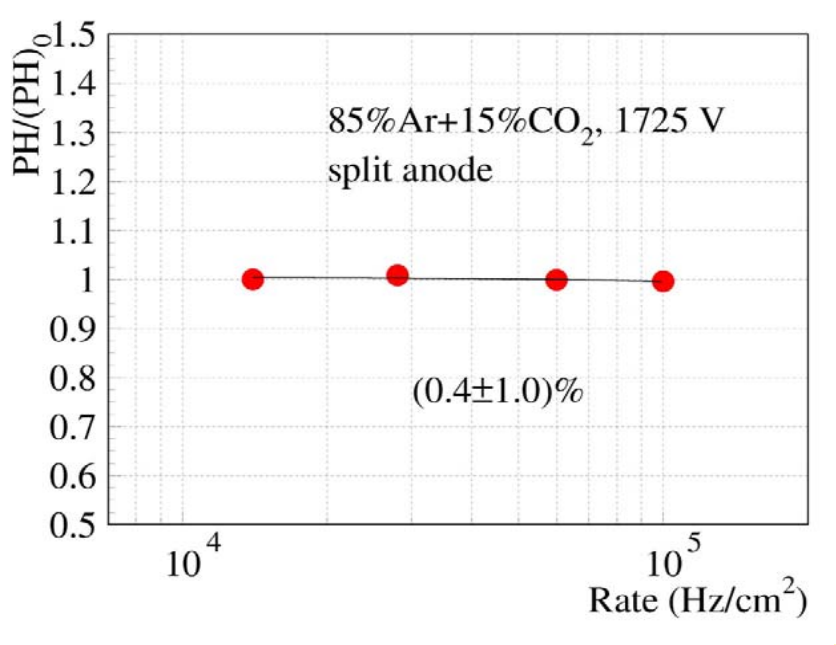
16 kHz/cm^2 counting rate

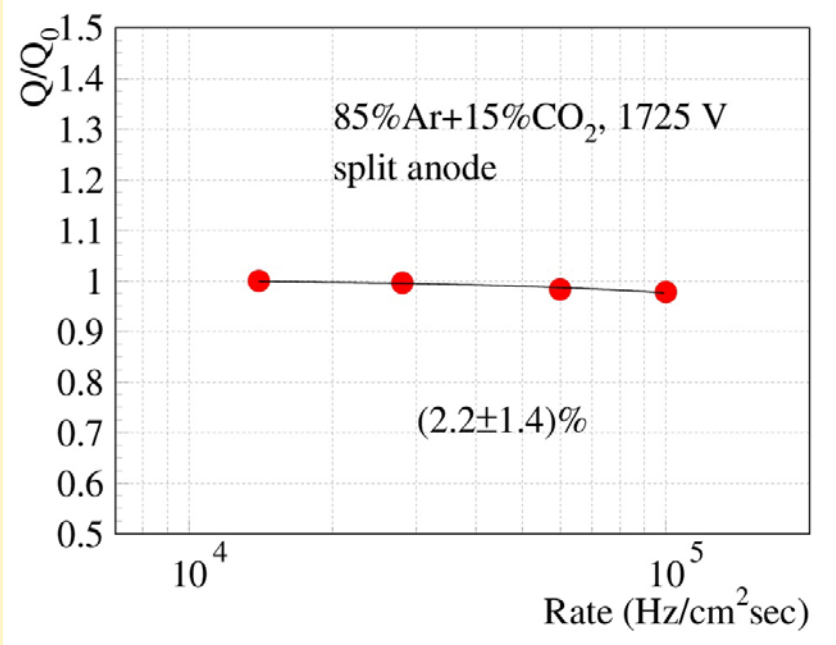
85%Xe + 15%CO_2

1800 V anode voltage

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

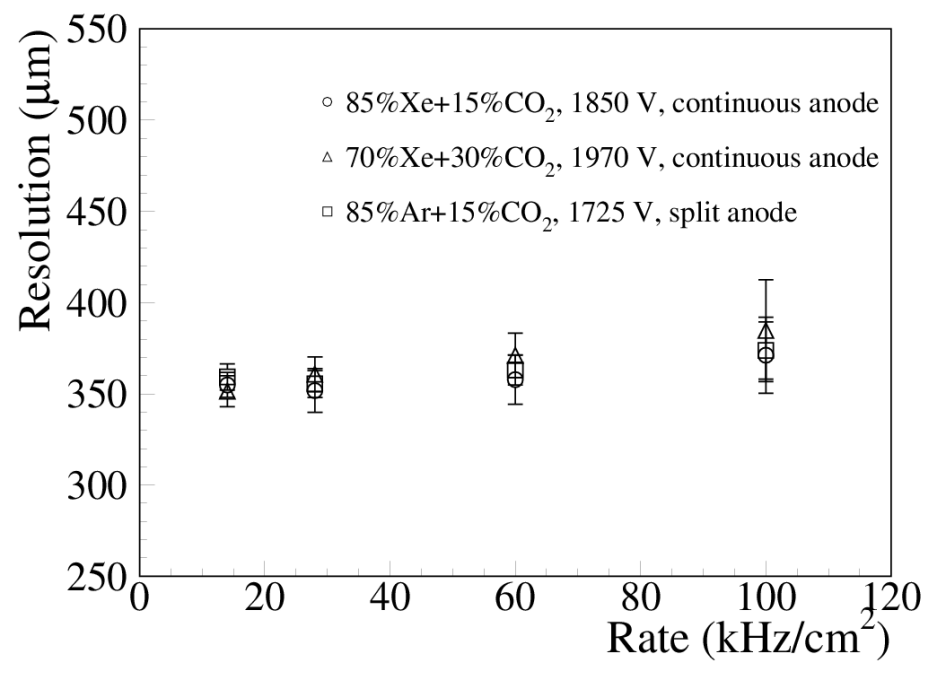
High Counting Rate Effect
Pulse Height and Charge





protons, p=2 GeV/c

High Counting Rate Effect
Position Resolution

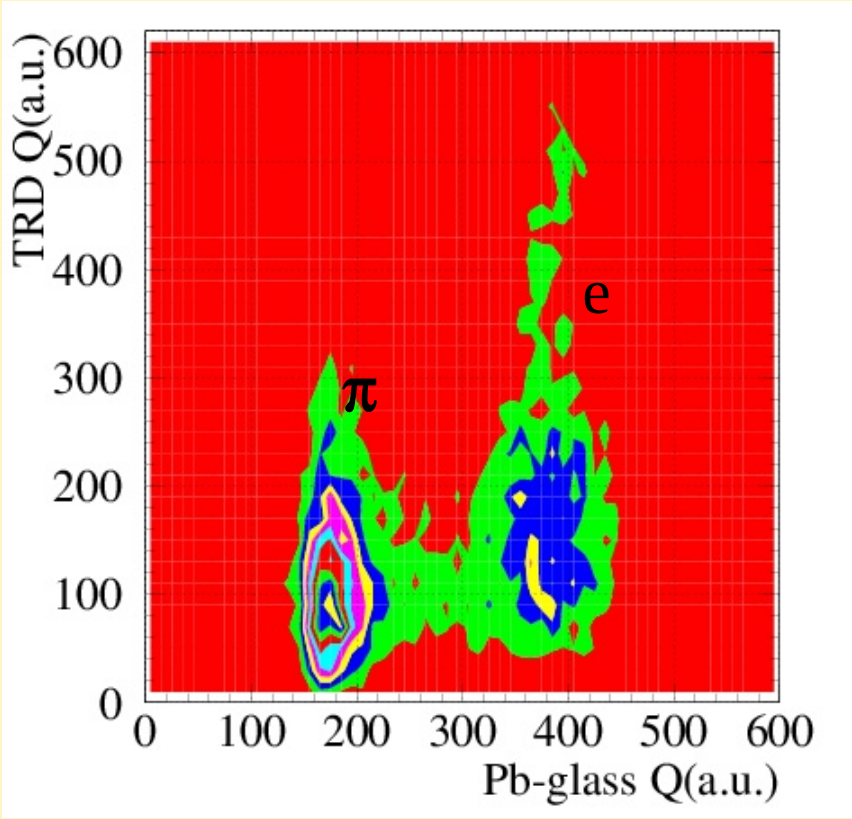


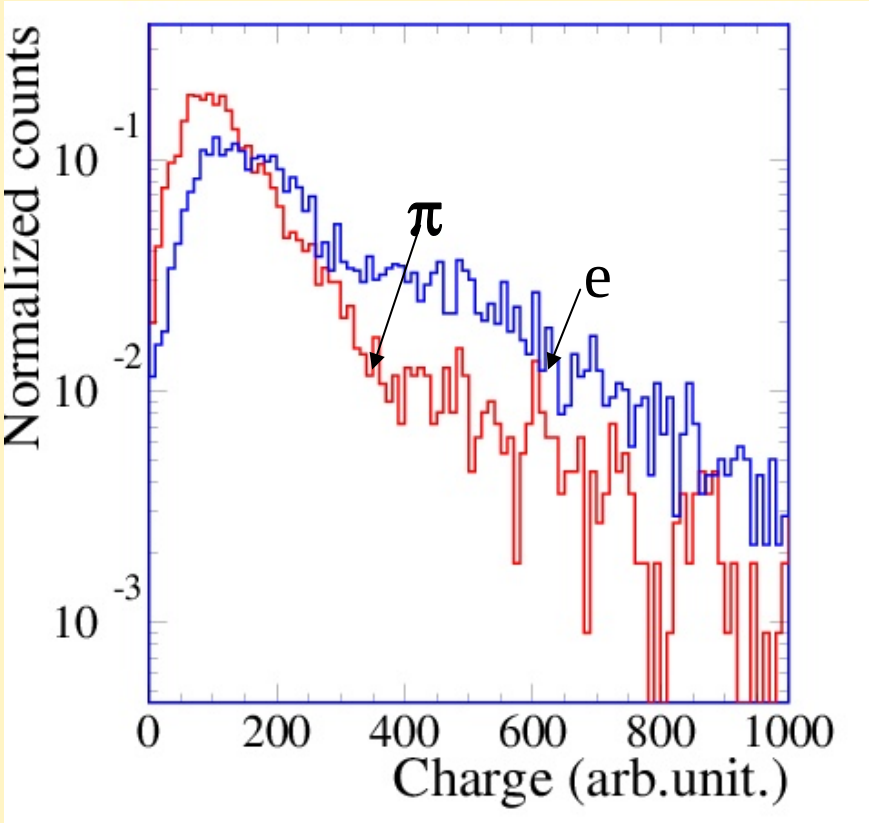
σ_{pos} = 350 μm @ 16 kHz/cm^2

σ_{pos} = 384 μm @ 100 kHz/cm^2

Pad geometry not optimized

e/π discrimination



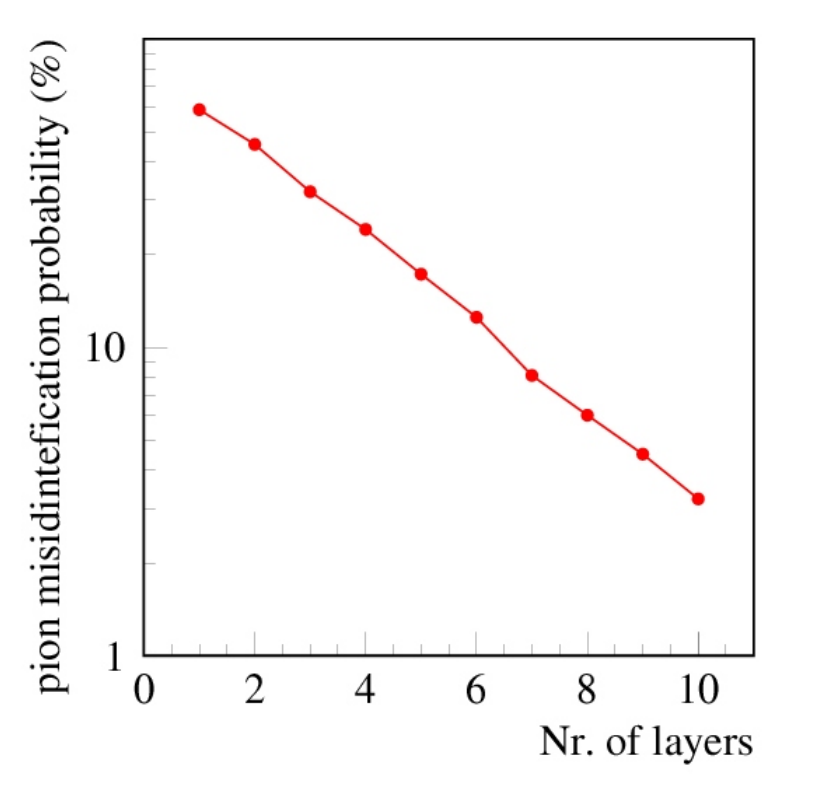


p=1GeV/c, U = 1900 V, Gas mixture: 85% Xe + 15% CO_2

Rohacell HF71 radiator

e/π Discrimination

1 GeV/c, Rohacell foam, 1900 V



Pion efficiency:

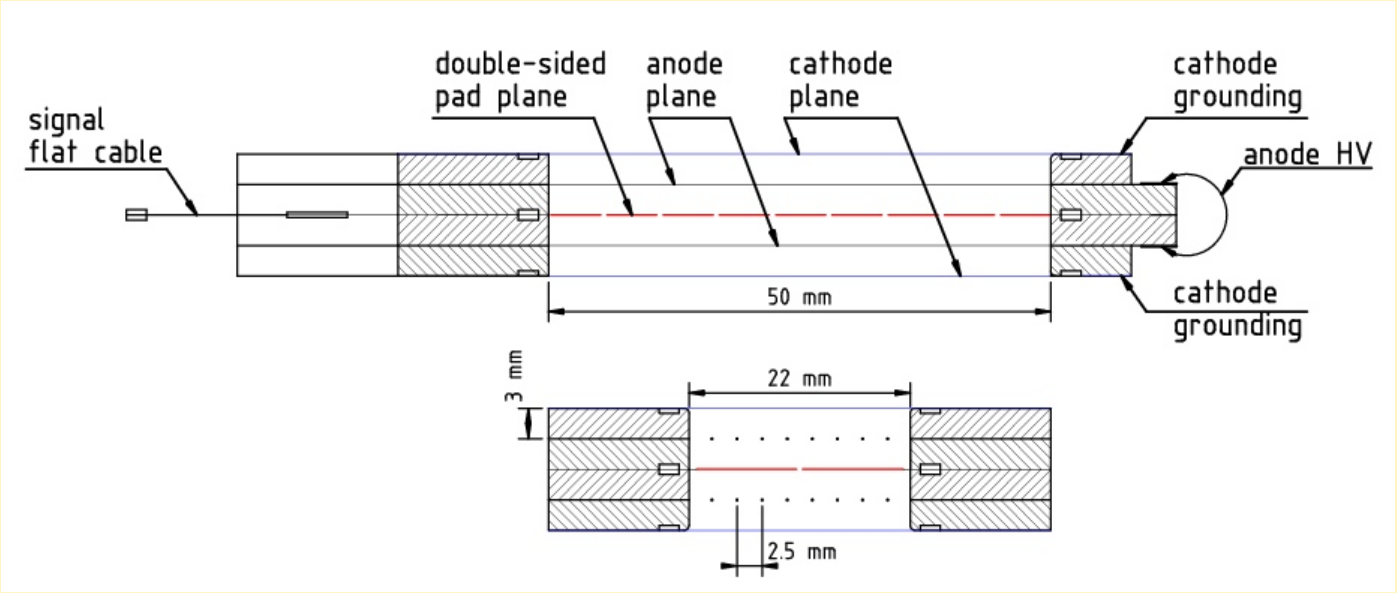
- *6 layers configuration = 12.5 %*
- *10 layers configuration = 2.9 %*
- *Can be improved using a better radiator from the point of view of the transition radiation yield*

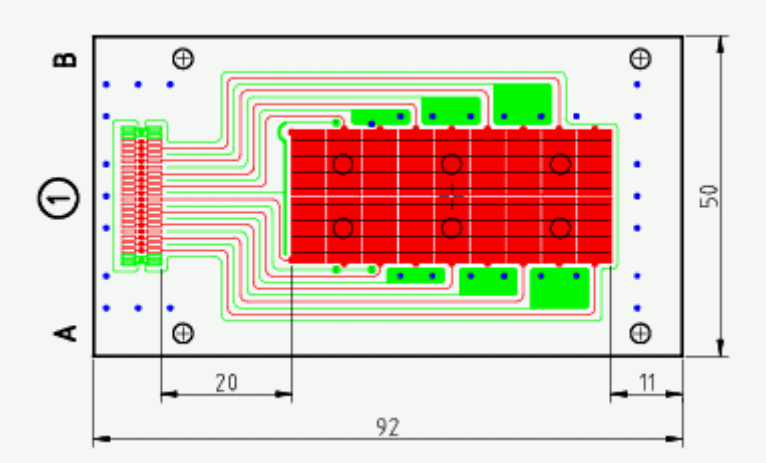
High Efficiency TRD for High Counting Rate Environment

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

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





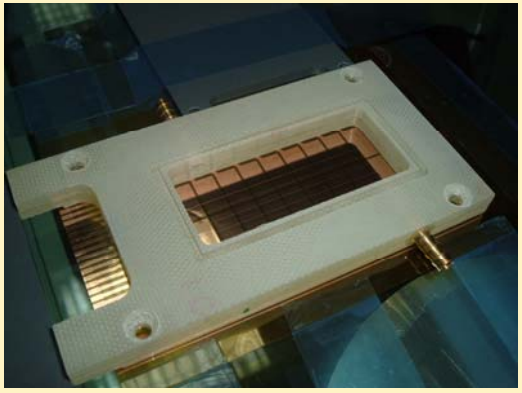
Readout electrode

pad size: 5 x 10 mm^2

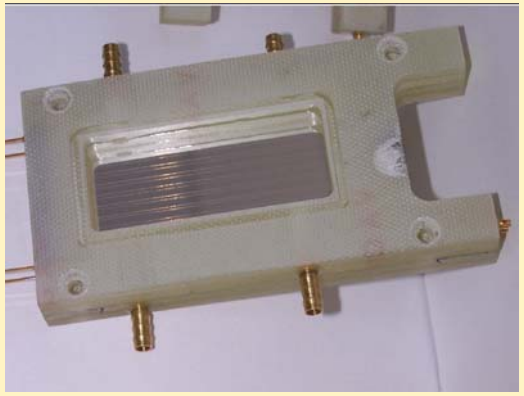
Three versions of such a prototype

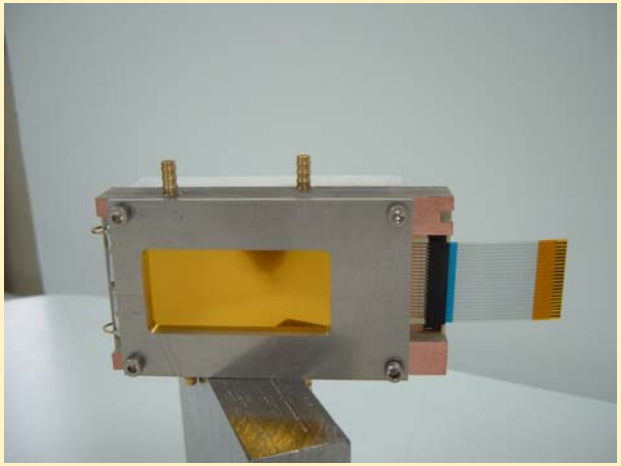
The first: ***the double – sided pad readout electrode has been made from PCB of 250 μm thickness.***

The third: ***the double – sided pad readout electrode made from kapton foil of 25 μm, covered with copper on both sides.***

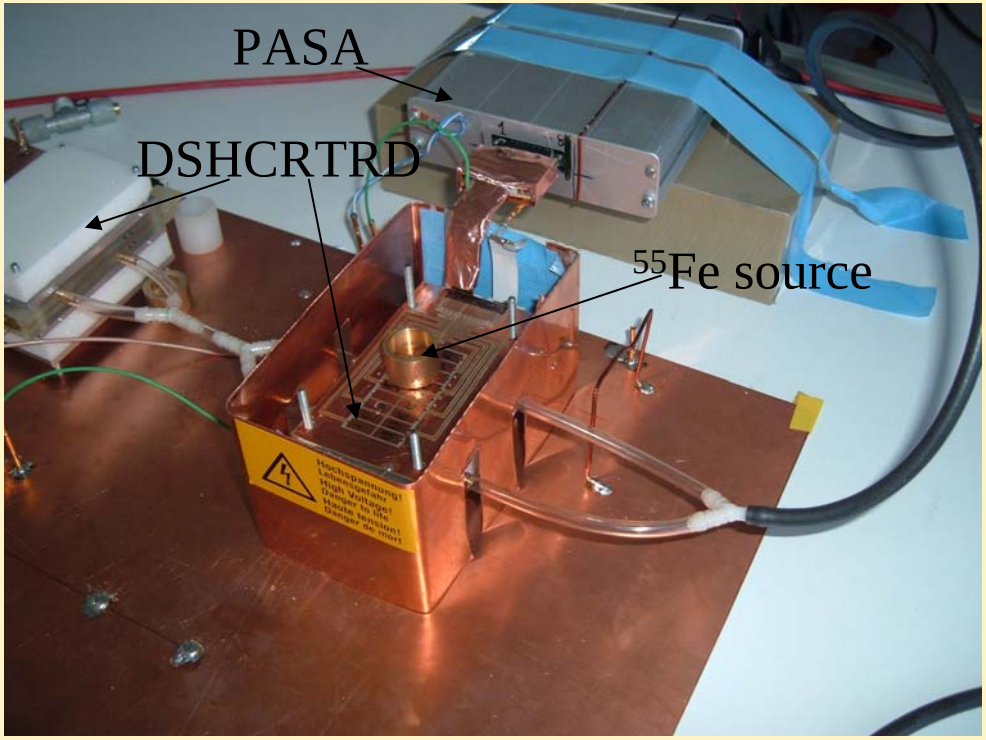


The second: ***the single – pad readout electrode made from mylar foil of 3 μm thickness, aluminized on both sides.***





^{55}Fe source tests

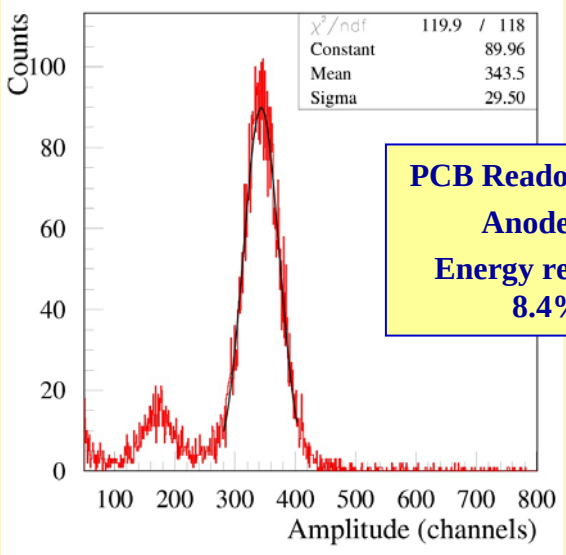


70% Ar + 30% CO_2 ;

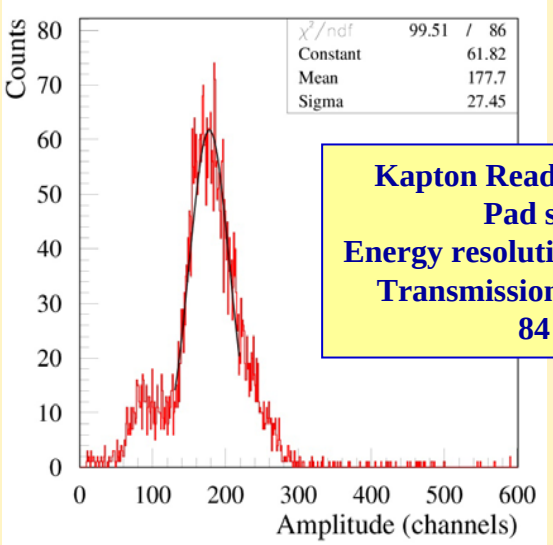
HV 1700 V;

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

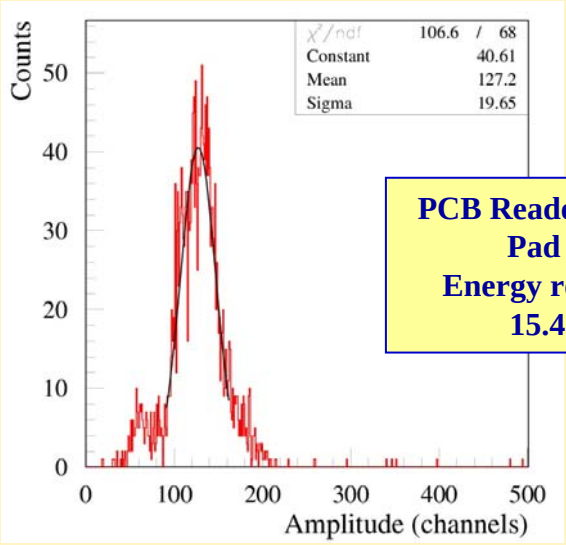
Results of the ^{55}Fe source tests



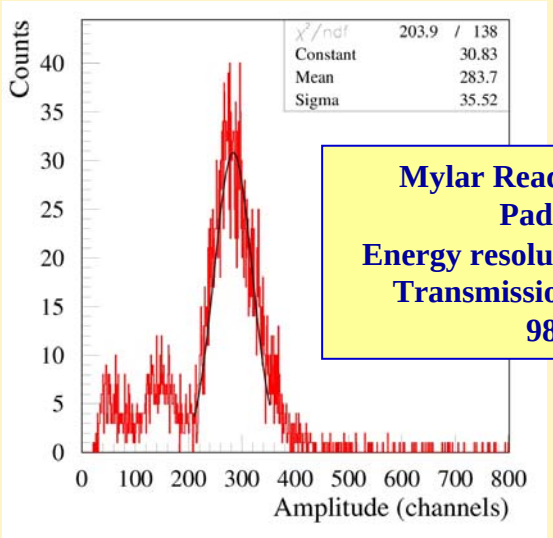
PCB Readout electrode
Anode signal
Energy resolution = 8.4% (σ)



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

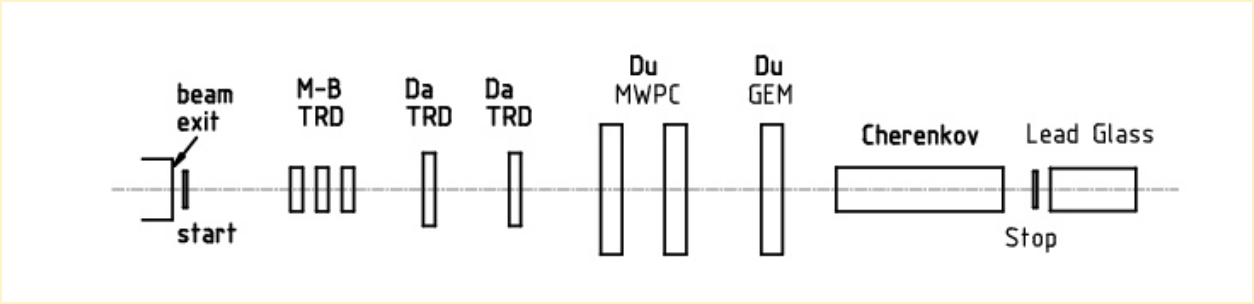


PCB Readout electrode
Pad signal
Energy resolution = 15.4% (σ)



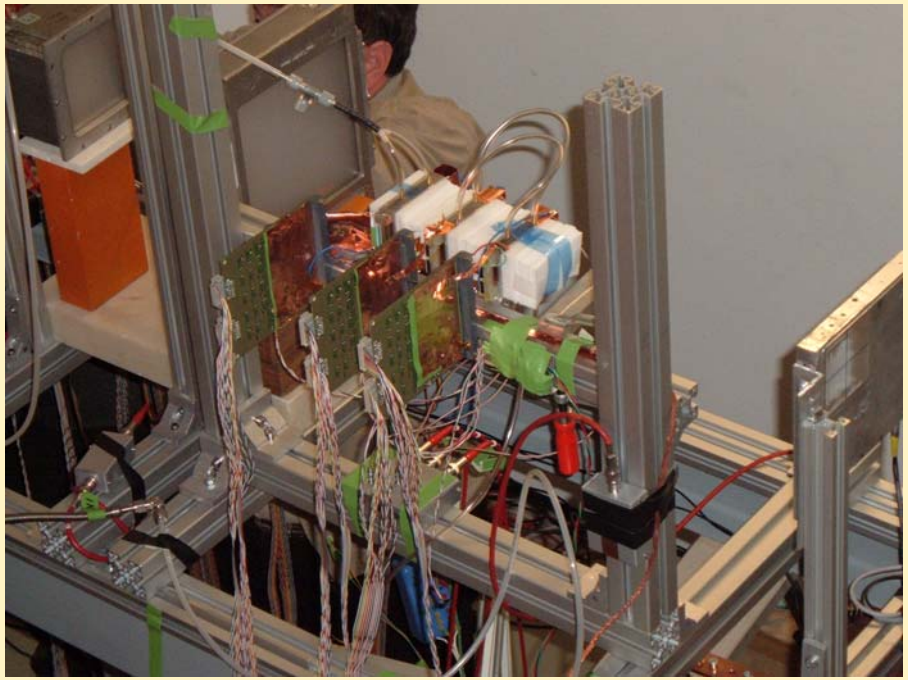
Mylar Readout electrode
Pad signal
Energy resolution = 12.5% (σ)
Transmission of X – ray = 98.5%

Beam tests



SIS, GSI – Darmstadt

Experimental Setup

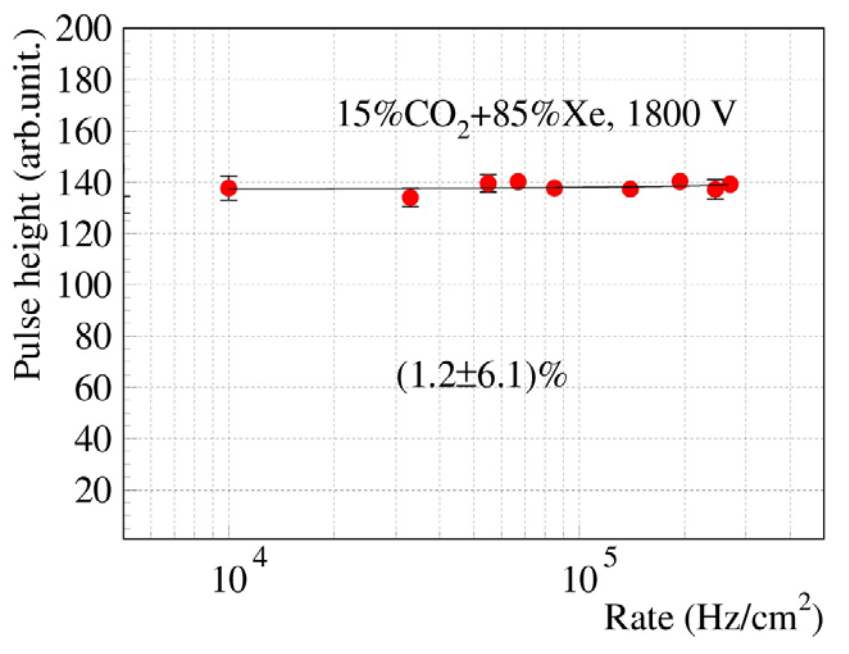


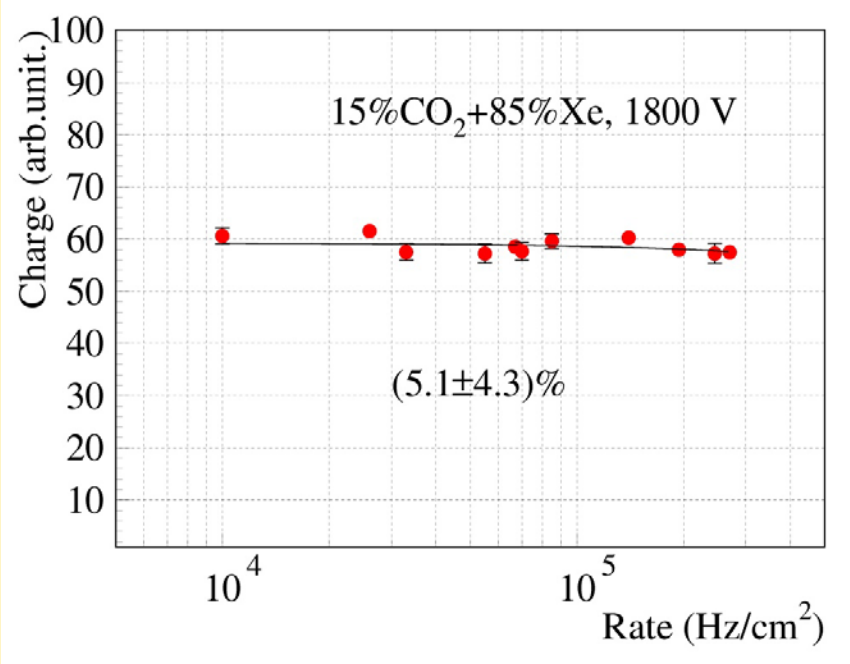
New PASA – 16 channels ASIC preamplifier - shaper

H.K. Soltveit, I.Rusanov, J.Stachel, GSI Sci. Rep. 2005-1

- **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)**
- **3 MWPC–IFIN-HH (18 pads with total area of ~ 22 x 50 cm^2)**
- **2 MWPC-GSI (32 pads with total area of ~ 56 x 64 cm^2)**
- **2 MWPC-JINR (active area 40 x 40 cm^2)**
- **1 GEM–JINR (active area 10 x 10 cm^2)**
- **Cherenkov detector + Pb-glass calorimeter**
- **FADC readout ; DAQ (MBS)**

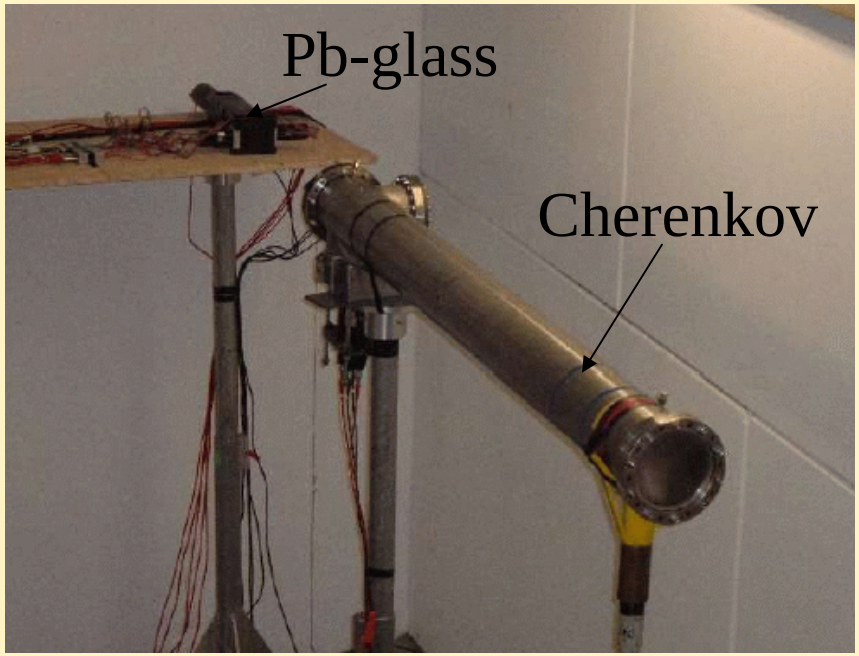
High Counting Rate Effect
Pulse Height and Charge

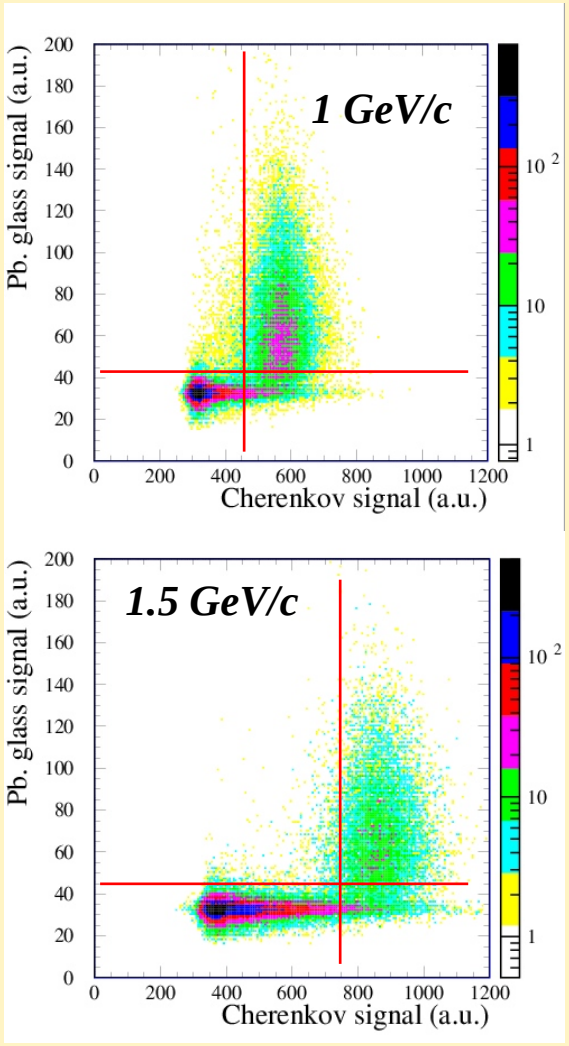




protons, p=1.5 GeV/c

Electron Identification

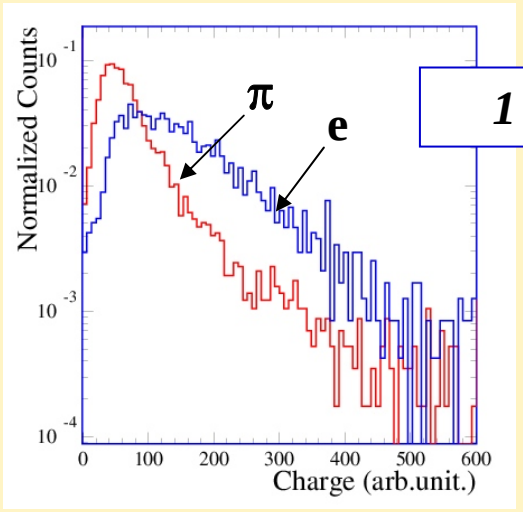




e/π discrimination performance

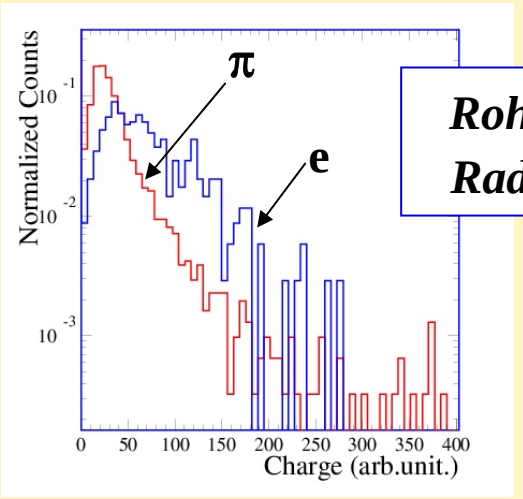
Rohacell Radiator = 4 cm fiber (17 μm) structure + 2 cm Rohacell foam, 1800 V

1.5 GeV/c, 1700 V

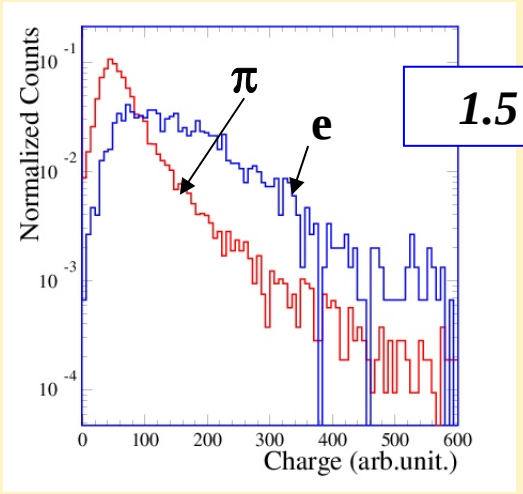


1 GeV/c

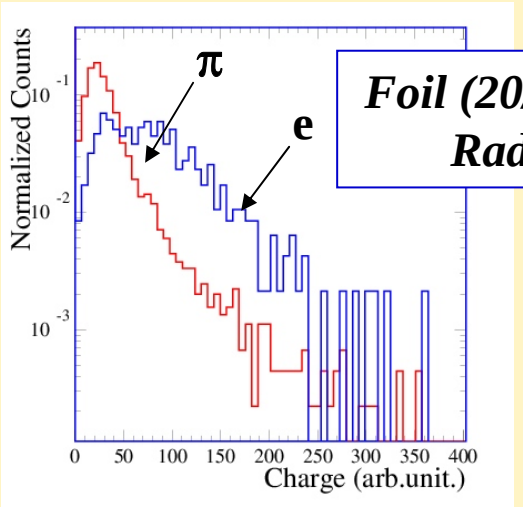
85%Xe + 15%CO_2



Rohacell Radiator



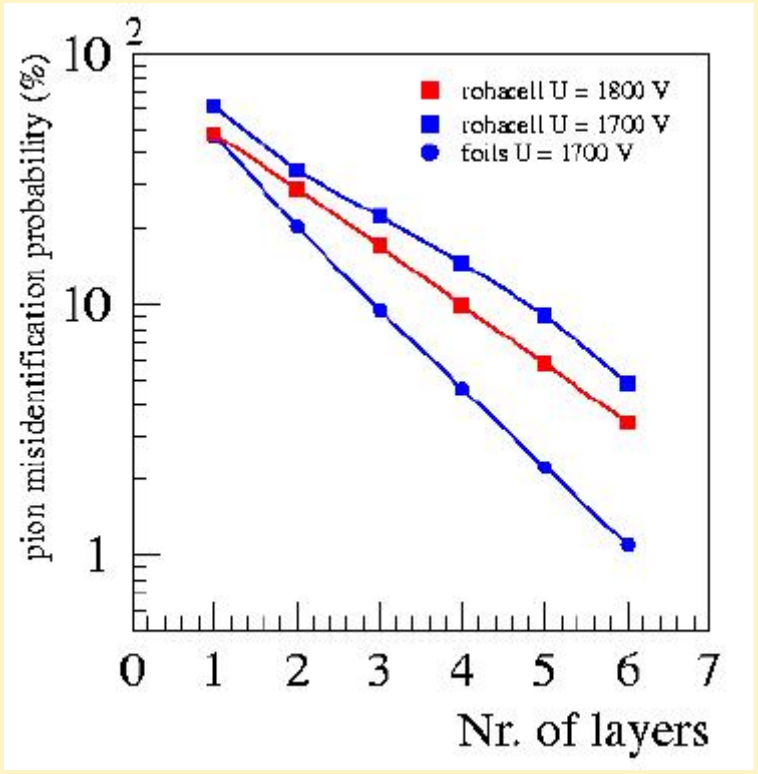
1.5 GeV/c



Foil (20/500/120) Radiator

e/pi discrimination performance

1.5 GeV/c



Pion eff @1700 V, rohacell = 5.4 %

Pion eff @1700 V, foils = 1.1 %

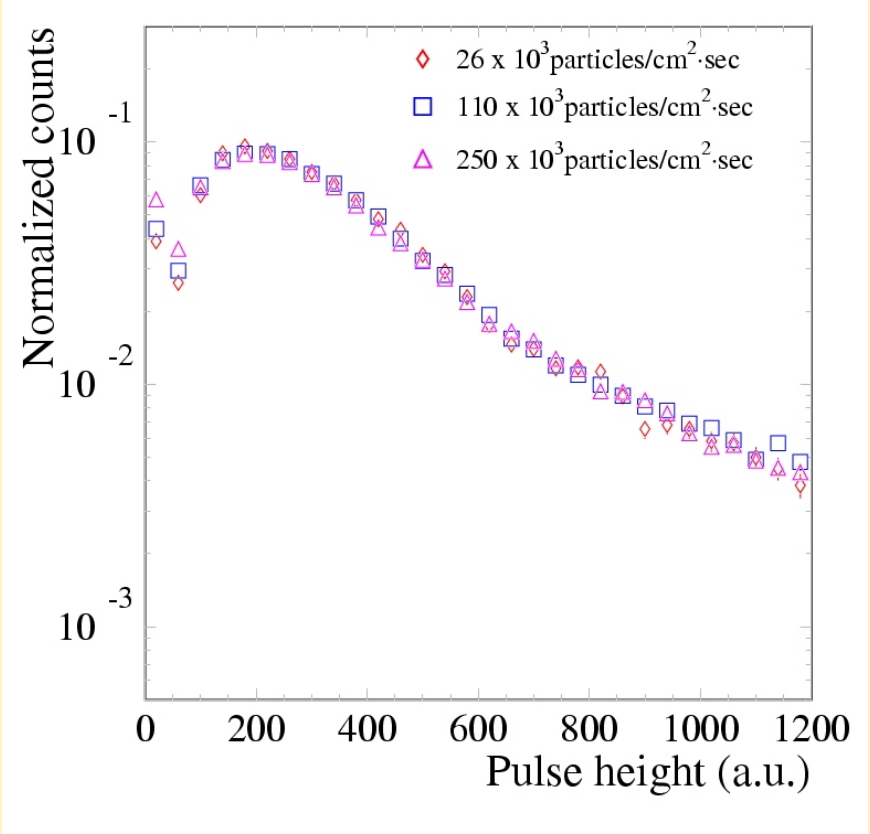
Pion eff @1800 V, rohacell = 3.3 %

Rohacell / foils = 4.9

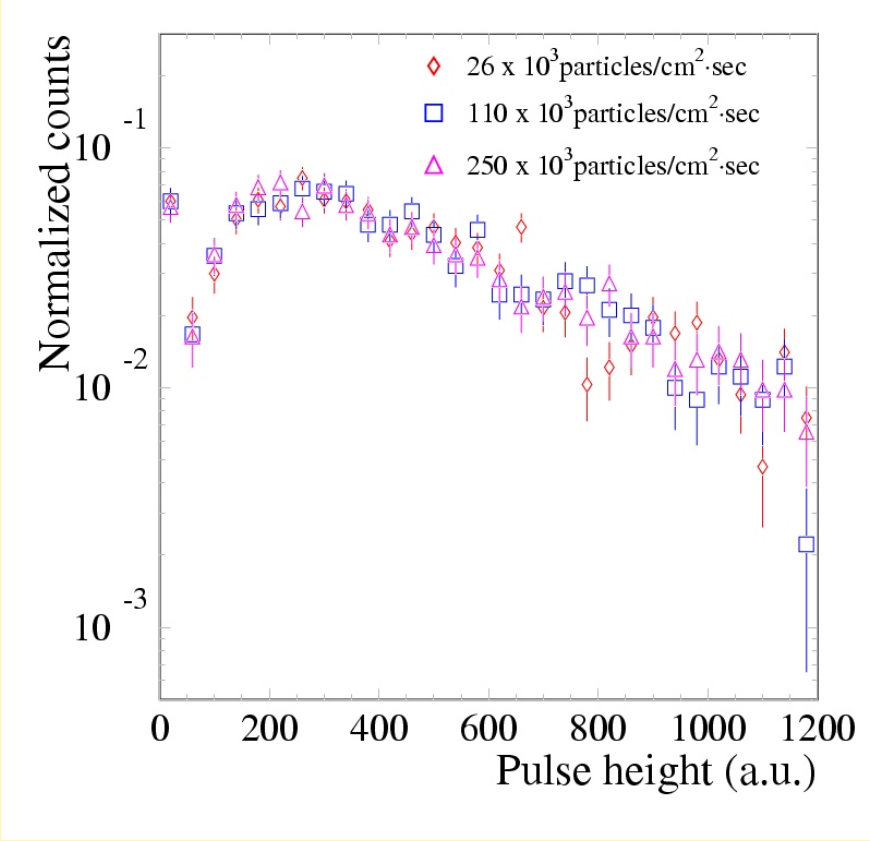
Pion eff @ 1800 V, foils = 0.67%

Rate performance

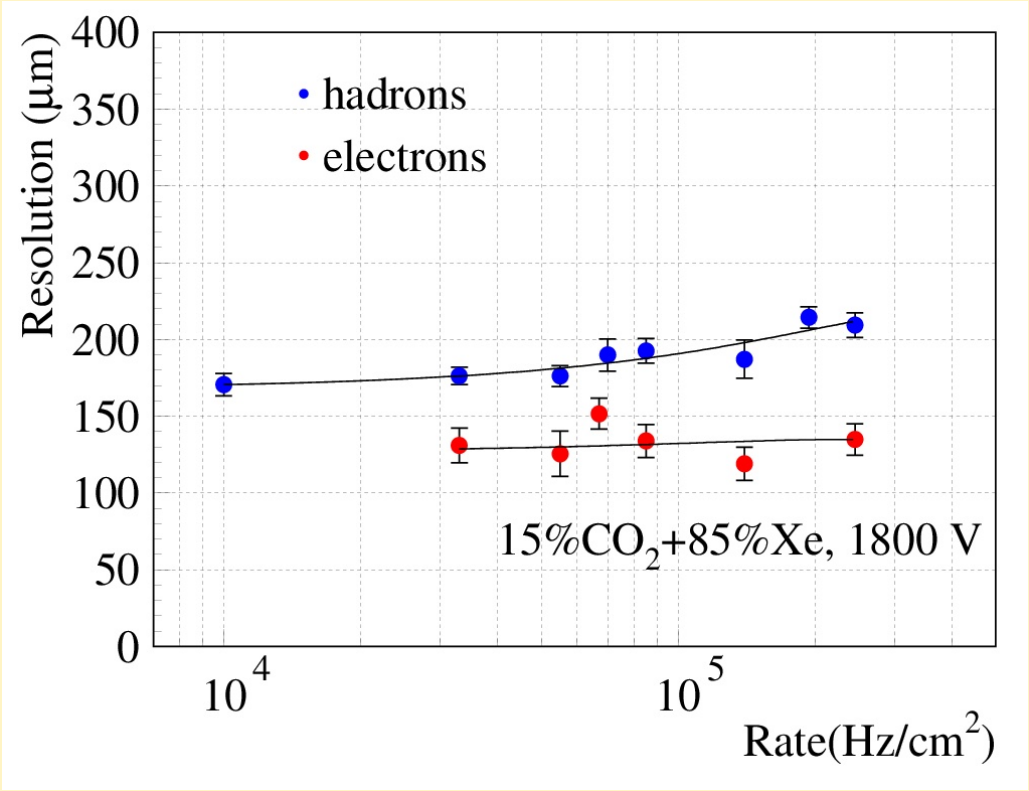
hadrons



electrons



Rate Dependence of the Position Resolution



No significant degradation up to 250 kHz/cm²

Conclusions

- *A High Counting Rate Transition Radiation Detector based on a simple Multiwire Proportional Chamber fulfills the requirements in terms of:*
  - ✓ *position resolution: smaller than 200 μm*
  - ✓ *pion efficiency: 12.5% for a 6 layer configuration @ p=1GeV/c, Rohacell radiator, 1900 V anode voltage*
  - ✓ *good performance up to 200 kHz/cm^2 counting rate*
- *An improvement of the pion rejection factor is obtained for such a double sided architecture and a six layer configuration relative to a simple Multiwire Proportional Chamber structure*
  - ✓ *estimated pion efficiency: 0.67% for six layers configuration @ p=1.5 GeV/c, regular periodic foil stack radiator (20/500/120), 1800 V anode voltage*
- *Such an architecture could be of interest for high efficiency muon detection in a high counting rate environment. (CBM is considering also the alternative of using muon detection as a solution to identify the short – lived mesons by their $\mu^+\mu^-$ decay).*

These results have been obtained in the frame of the JRA4 - I3HP/FP6 Collaboration:

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