Work package: 19

Activity number and acronym: FuturePID

Future Particle Identification Techniques

Work package title:

Detector and electronics development for large-area low-mass self-triggered gaseous detectors

Participating Institutes:

Westfälische Wilhelms-Universität Münster WWU	*- J. Wessels*
GSI Helmholtz Zentrum	*- A. Andronic*
Ruprecht-Karls-Universität Heidelberg	*- J. Stachel*
National Institute for Physics and Nuclear Engineering - Bucharest	*- M. Petrovici*
Forschungszentrum Dresden-Rossendorf	*- L. Naumann*
Rudger Boskovic Institute - Zagreb	*- M. Kis*

Other involved institutions not receiving EC funds:

Tsinghua University	*- Y. Wang*

Deliverables:

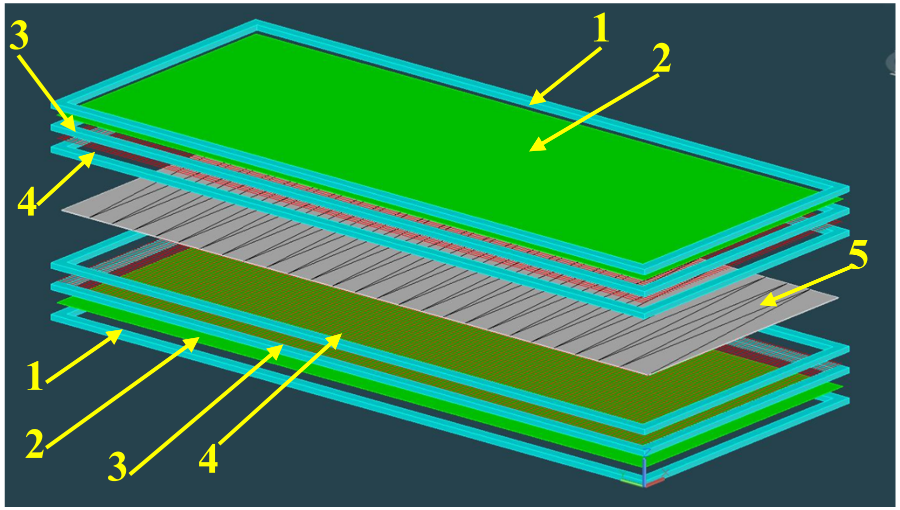
TRD:

- *Radiator simulation and construction*
- *Position reconstruction algorithms*
- *Large area, high granularity, two dimensional position sensitive high counting rate TRD*

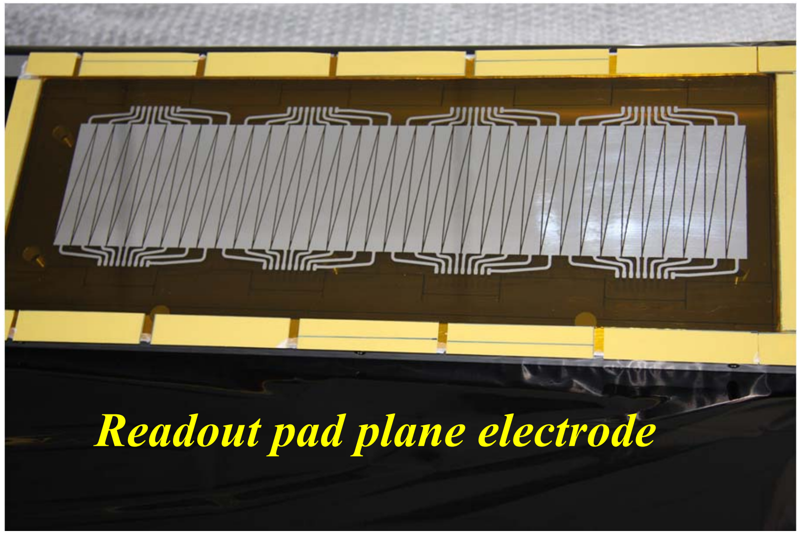
RPC:

- *Studying the possibility to decrease even further the cluster size that depends on the architecture of the HV electrodes, the thickness of the resistive electrodes and number of gaps*
- *FEE*
- *Integration and test*
- *System performance*

Two dimension position sensitive DSTRD Prototype
Short history (I)



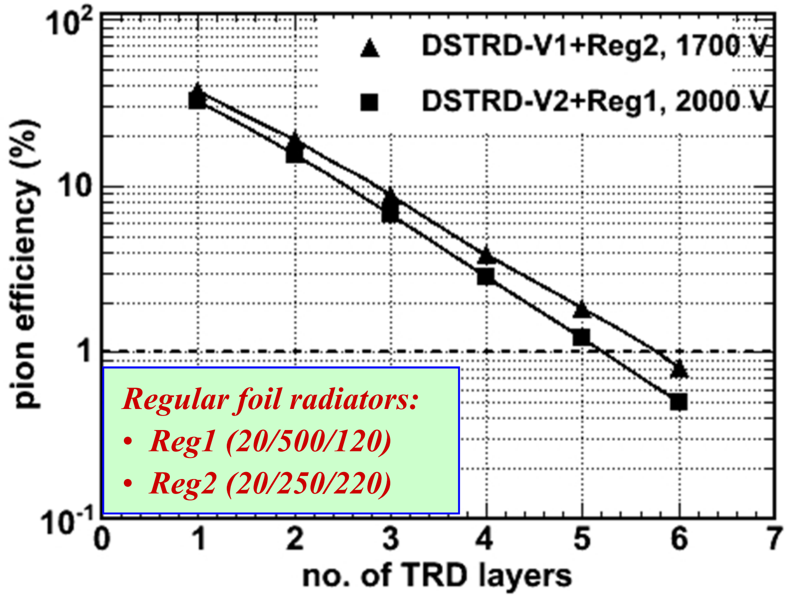
1. cathode frame
2. cathode plane – 25 μm Al kapton foil stretched on a 8 mm rohacell plate
3. anode wires (20 μm W/Au) + frame
4. distance frame
5. 36 cm x 8 cm readout electrode: 72 triangular pads



Readout pad plane electrode

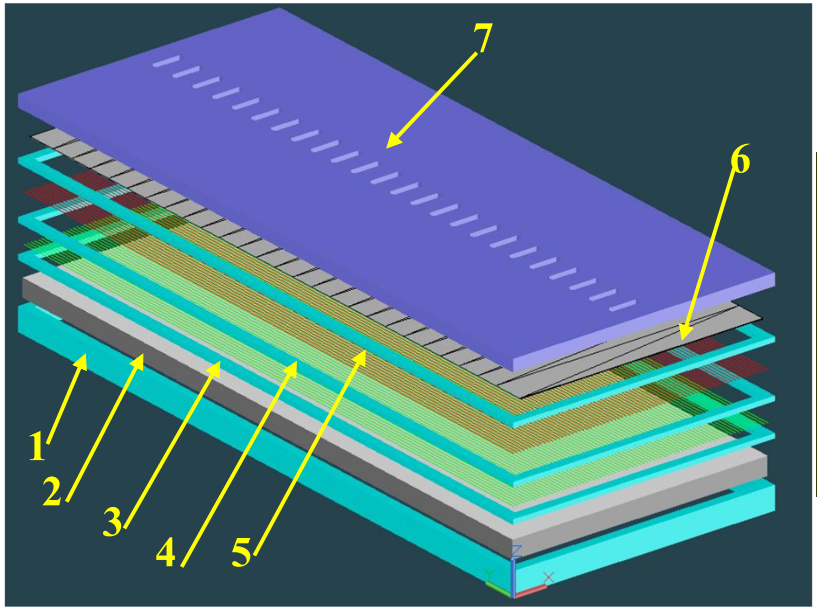
- *2 MWPC readout by the a common double sided pad plane*
- *readout electrode: Cr(20 nm)/Al(200nm) on 25μm kapton foil*
- *triangular shape of readout pads*
- *readout cell area (1 x 8)/2 cm^2 = 4 cm^2*
- *3 mm anode wire pitch*

Two versions:
DSTRD-V1 of 3 mm anode – cathode gap
DSTRD-V2 of 4 mm anode – cathode gap



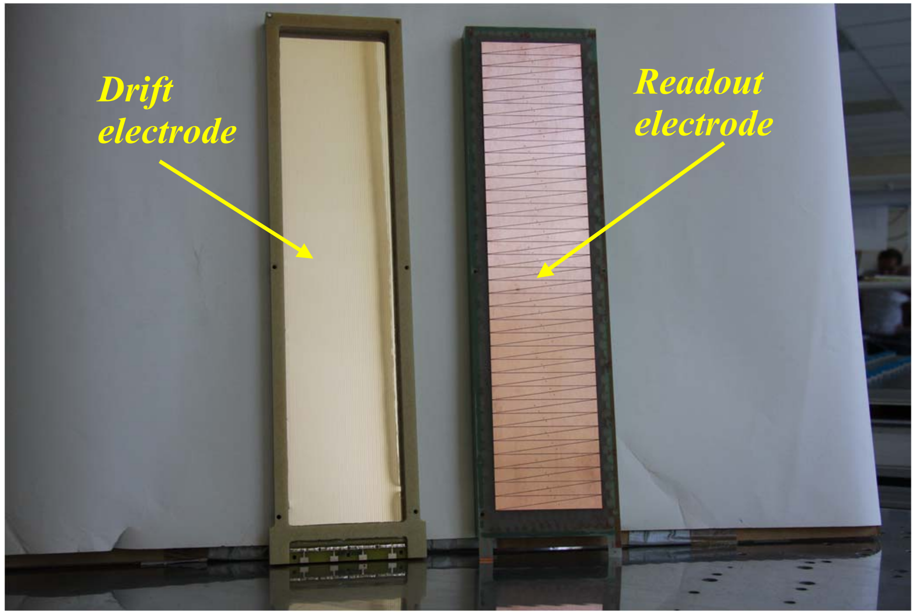
M. Petris et al., Nucl. Instr. and Meth. A 714 (2013), 17

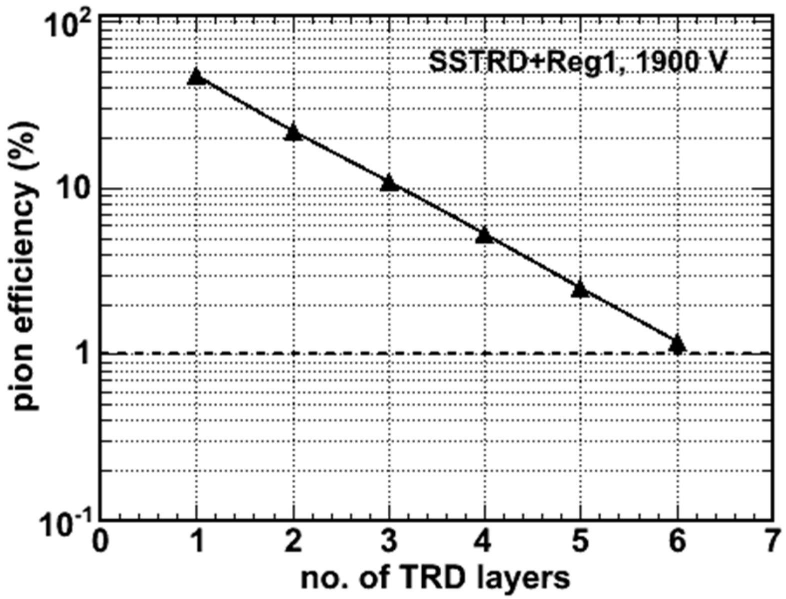
Two dimension position sensitive SSTRD Prototype
Short history (II)



1. drift electrode frame
2. drift electrode
3. cathode wires + frame
4. anode wires + frame
5. distance frame
6. readout electrode
7. honeycomb panel

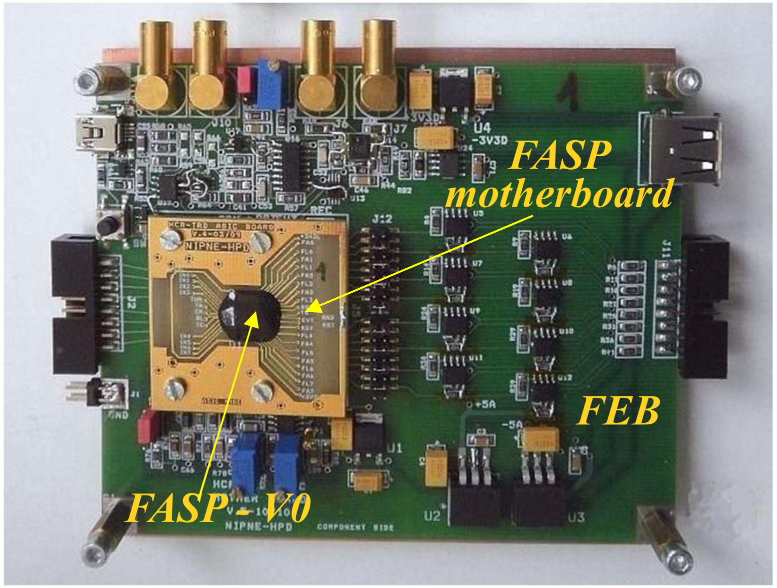
- single MWPC + 4 mm drift region
- 4 mm anode – cathode gap
- 3 mm anode wire pitch
- 1.5 mm cathode wire pitch
- drift electrode = Al kapton foil stretched on 8 mm Rohacell plate
- readout electrode 300 µm pcb
- triangular shape of readout pads
- readout cell area (1 x 8)/2 cm^2 = 4 cm^2





M. Petris et al., Submitted to Proceedings of the Vienna Conference on Instrumentation 2013

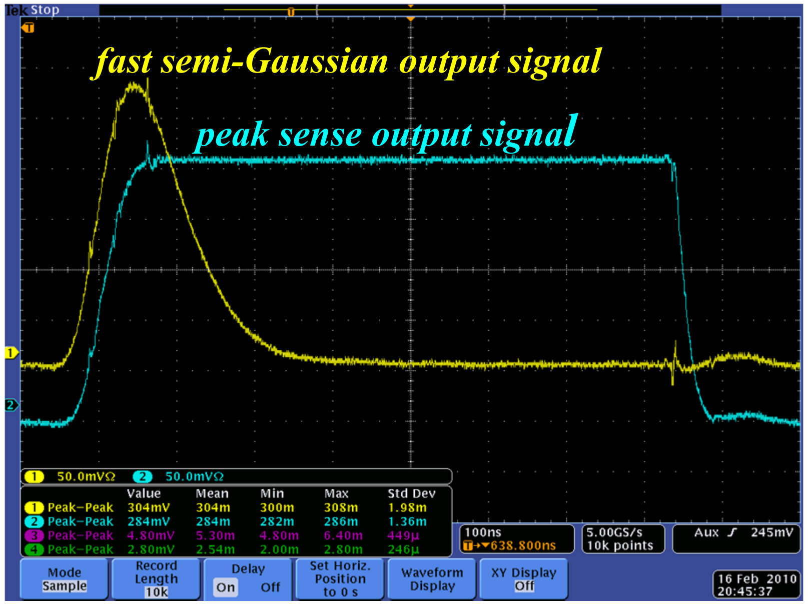
Fast Analog Signal Processor - FASP

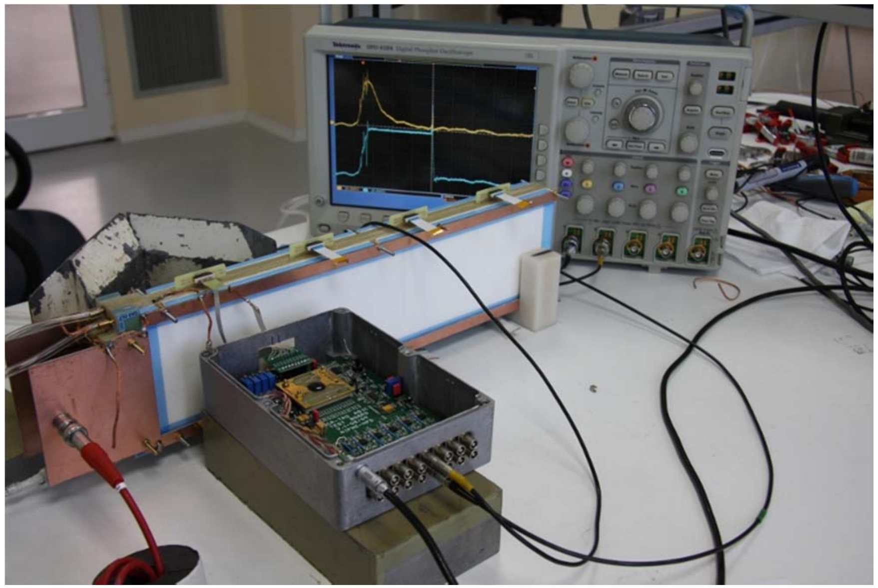


First version – FASP-VO

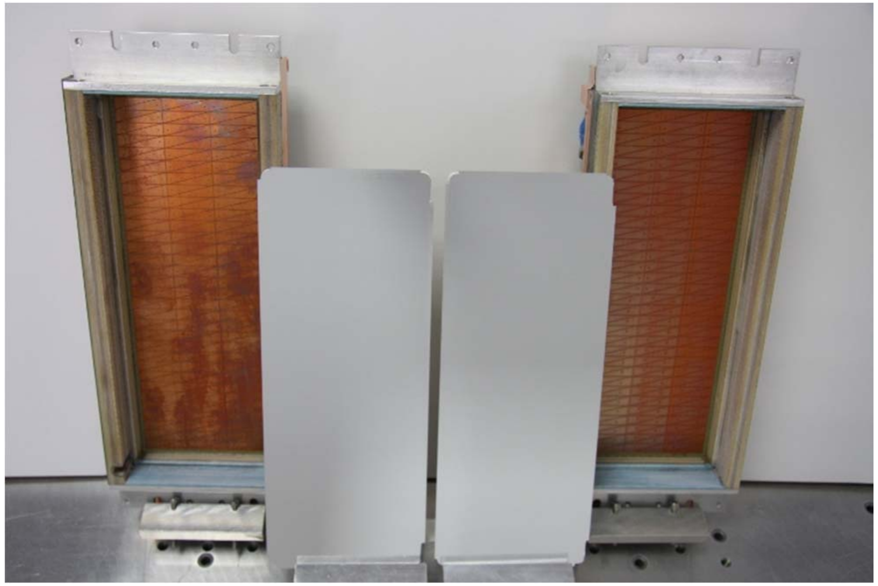
- *Designed in AMS CMOS 0.35 μm technology*
- *Gain: 6.2 mV/fC*
- *Selectable shaping time (ST): 20 ns and 40 ns*
- *Noise (C_{in} = 25pF): 980 e^-@40 ns ST and 1170 e^-@20 ns ST*
- *Power consumption = 11 mW/channel*
- *Variable threshold*
- *Self trigger capability*
- *8 input/output channels*

Analog channel outputs

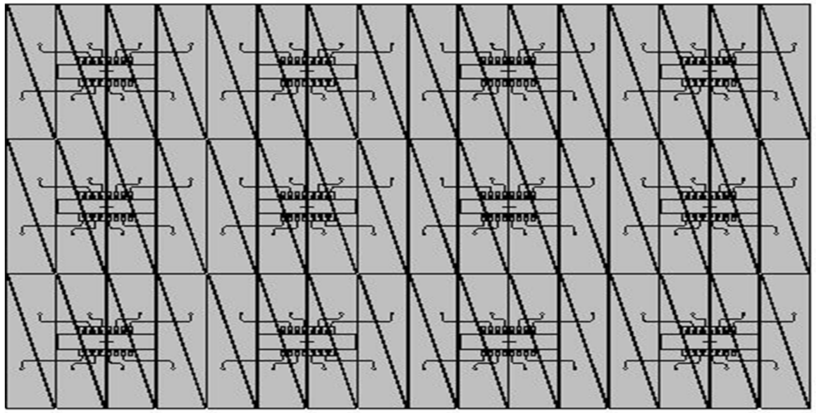




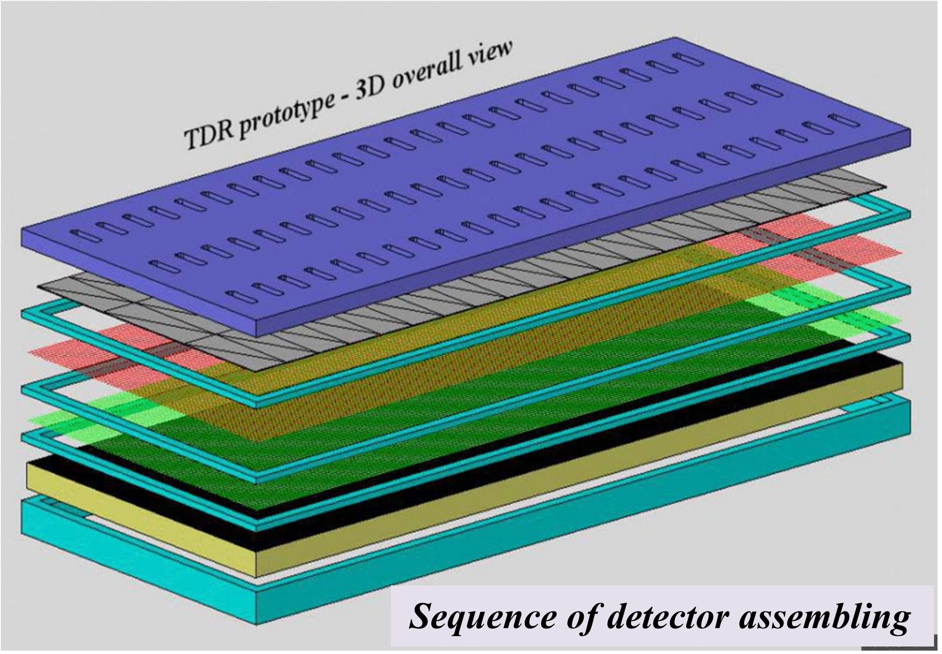
High granularity TRD prototype design



- *single MWPC + 4 mm drift region*
- *4 mm anode – cathode gap*
- *3 mm anode wire pitch*
- *1.5 mm cathode wire pitch*
- *readout electrode 300 μm pcb*
- *drift electrode = 20 μm Al kapton + 8 mm Rohacell*
- *triangular shape of readout pads*
- *readout cell area (0.7 x 2.7)/2 cm² ≈ 1 cm²*



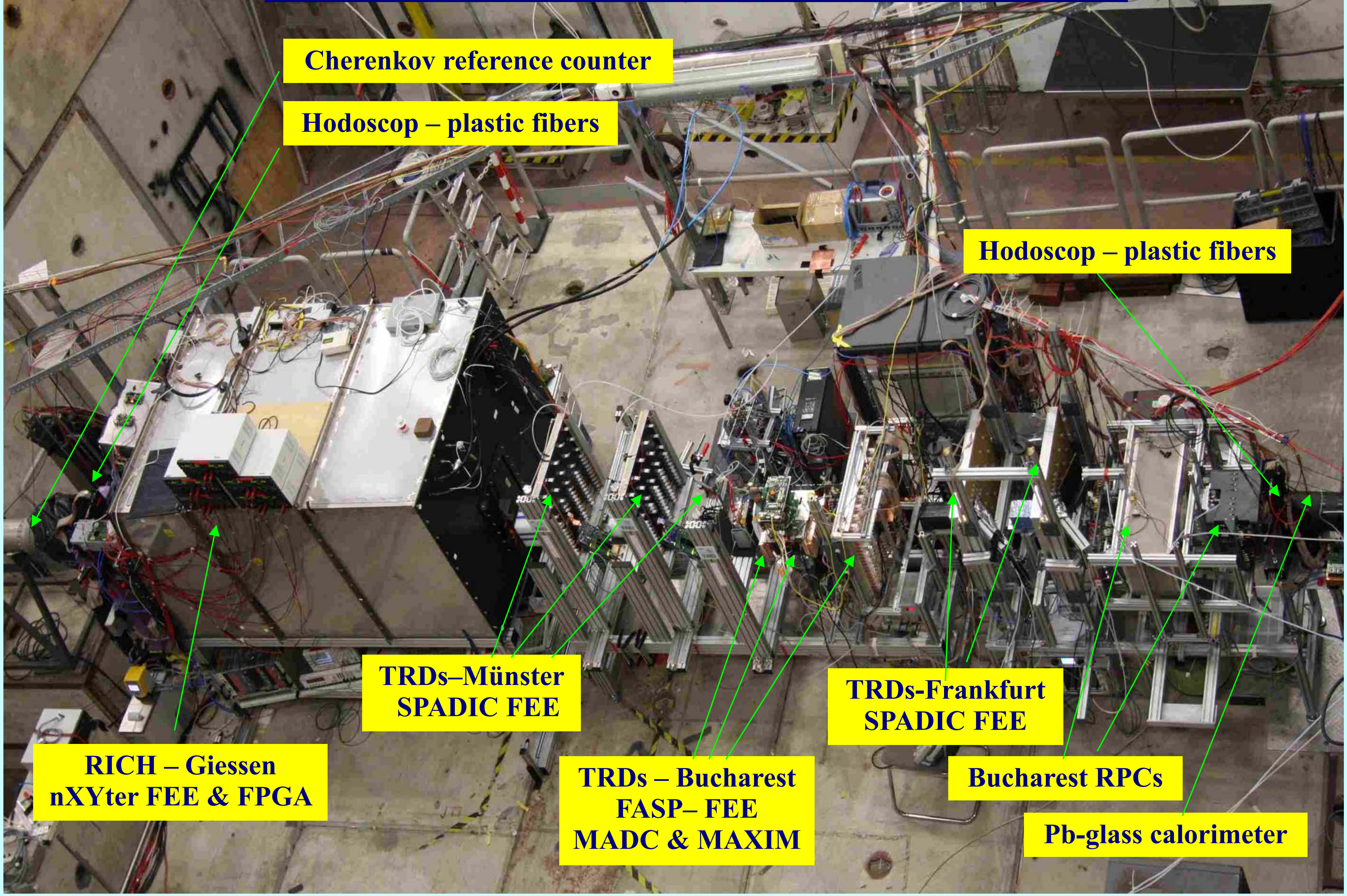
192 triangular pads with
a total area of 8.5 x 23 cm²



Sequence of detector assembling

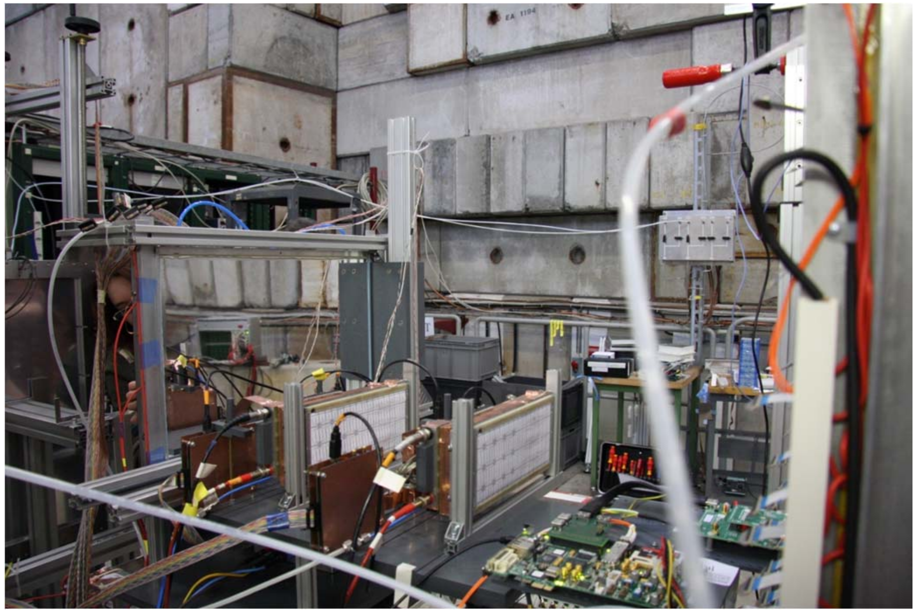
Experimental setup

In-beam test @ T9 beam line of CERN PS



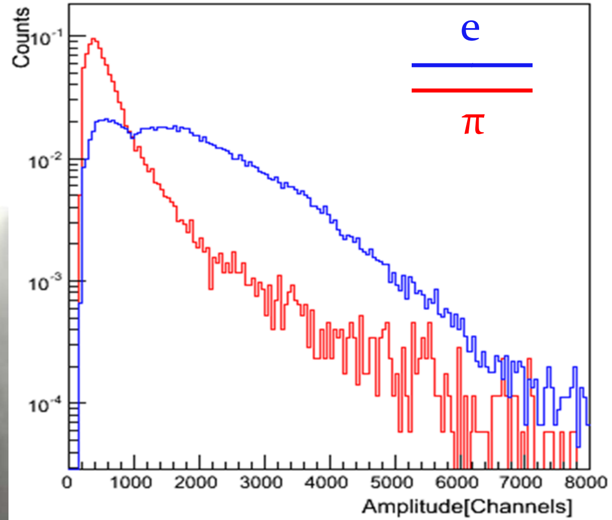
e/π discrimination

In-beam test @ T9 beam line of CERN PS



FEE – FASP – flat top output, 40 ns shaping time

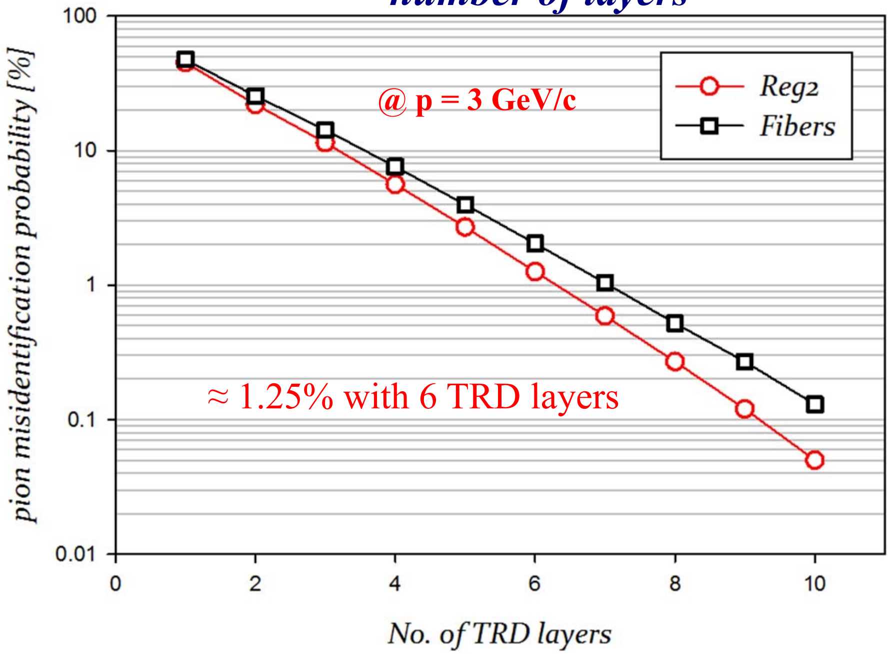
Pulse height distribution for electrons and pions @ 2 GeV/c



regular foil radiator Reg2

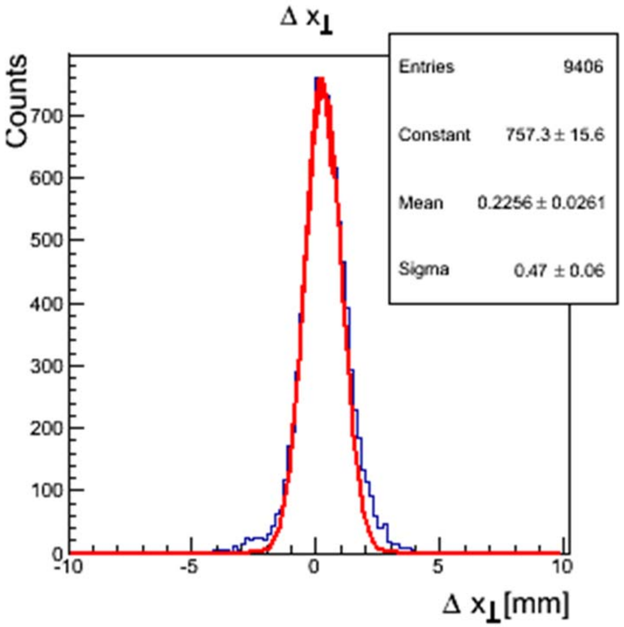
HV_A= 2000 V; HV_D= 800 V

Pion efficiency as a function of number of layers



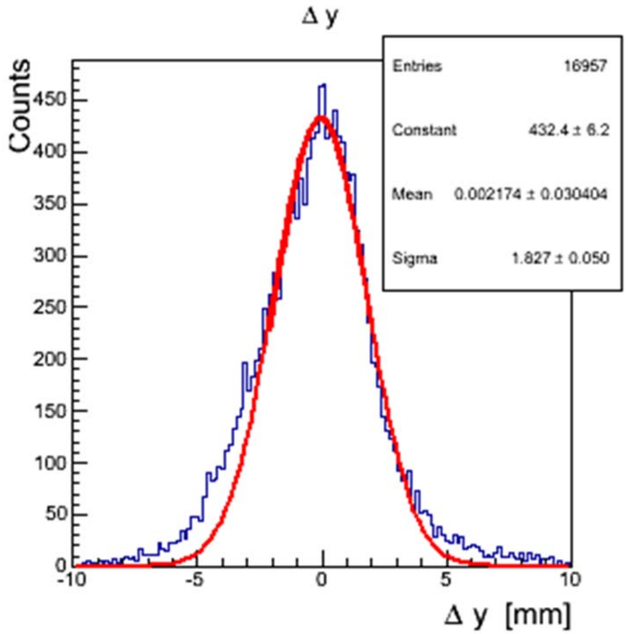
Position Resolution

position resolution across the pads



$\sigma_x = 330\ \mu m$

position resolution along the pads

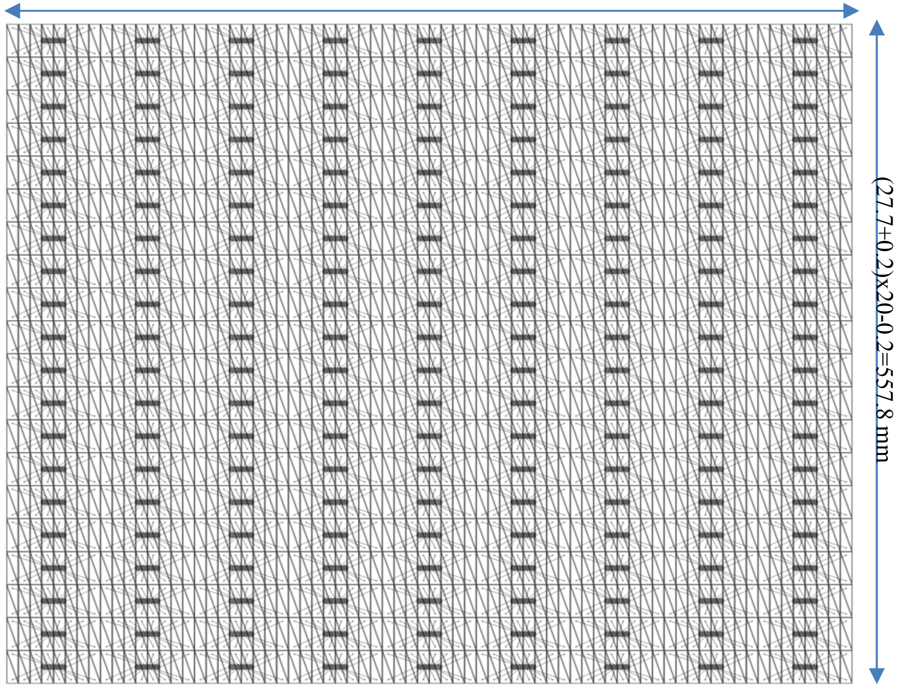


$\sigma_y = 1.3\ mm$

Pad size = 0.7 cm x 2.7 cm

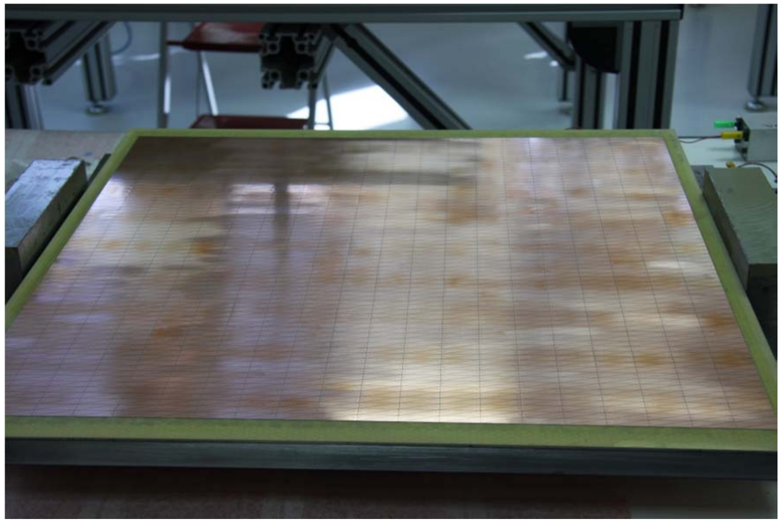
Next step -Toward a TRD basic cell for the inner zone of CBM-TRD detector

(7.3+0.2)x72-0.2=539.8 mm



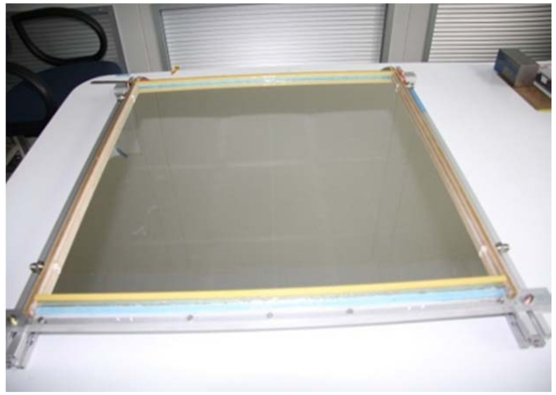
20 rows x 144 triangular pads/row = 2880 readout channels

readout cell area (0.7 x 2.7)/2 cm² ≈ 1 cm²

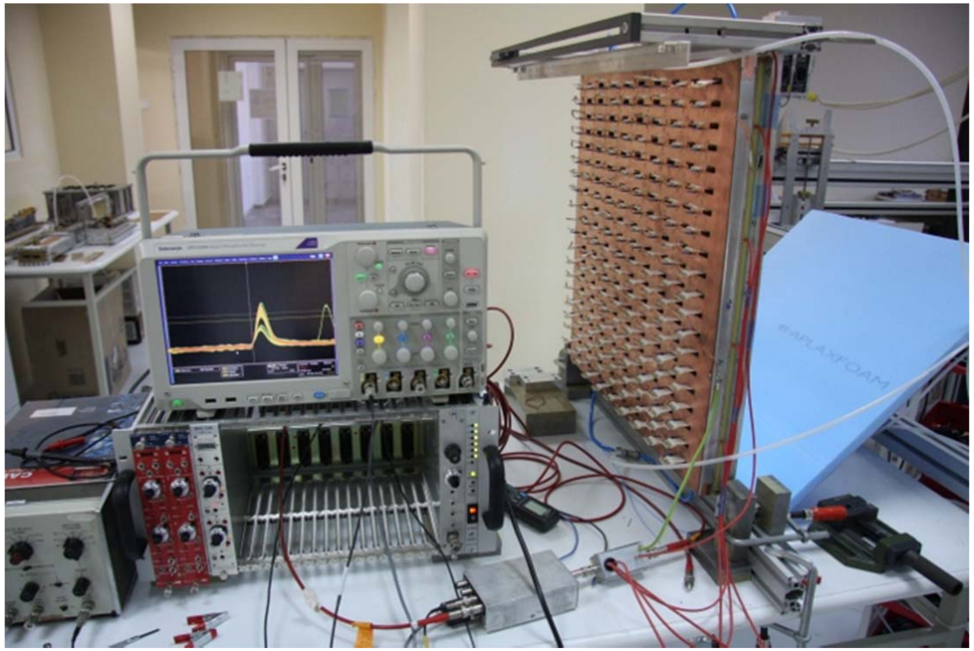


Drift electrode

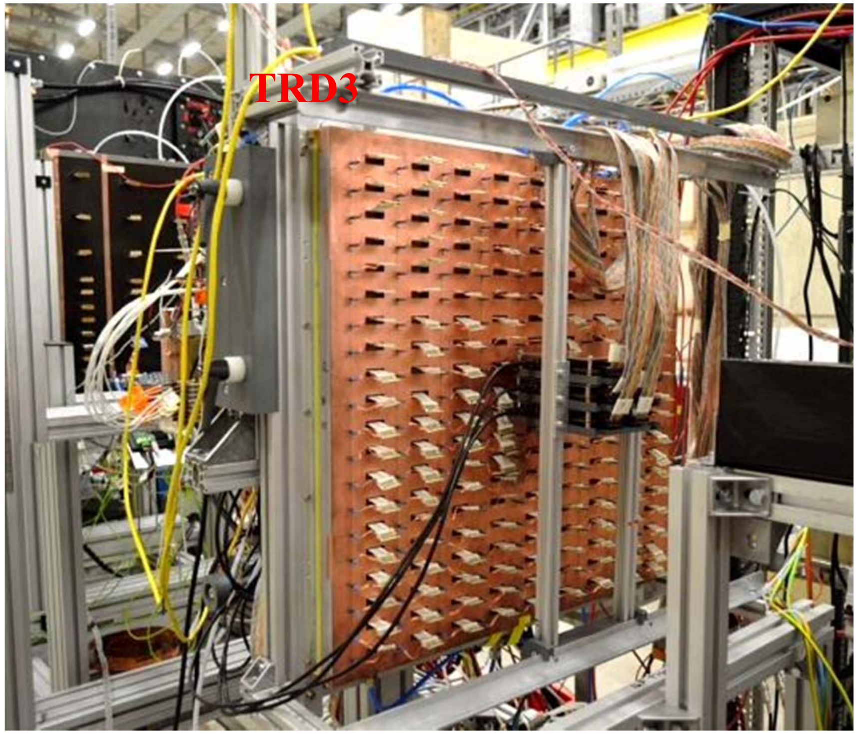
Al-kapton/3mm Rohacell/9 mm honeycomb/3 mm Rohacell/Al-kapton

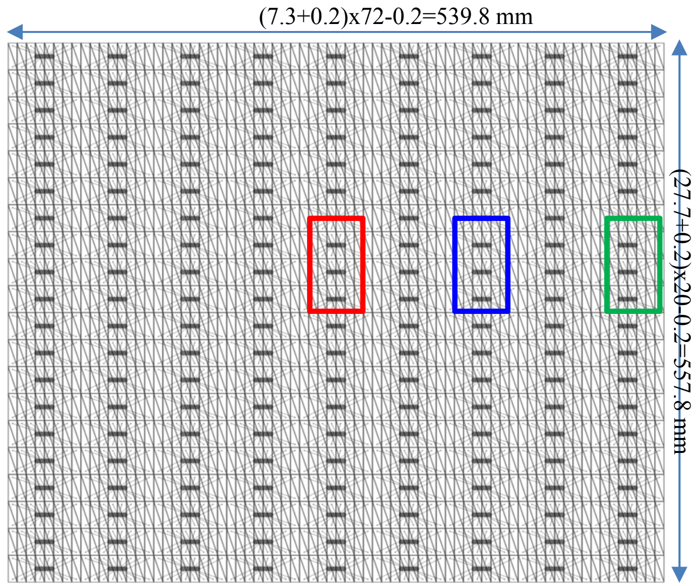


^{55}Fe source test in DetLab

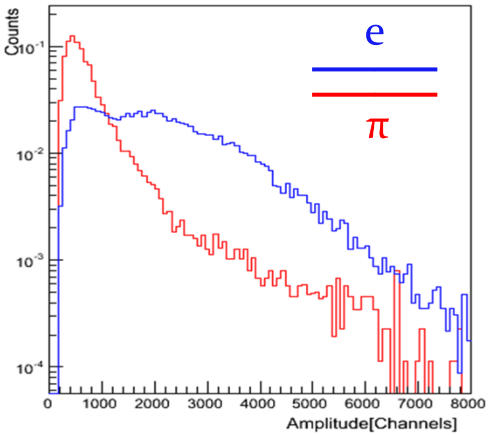


e/π discrimination TRD 2012 prototype

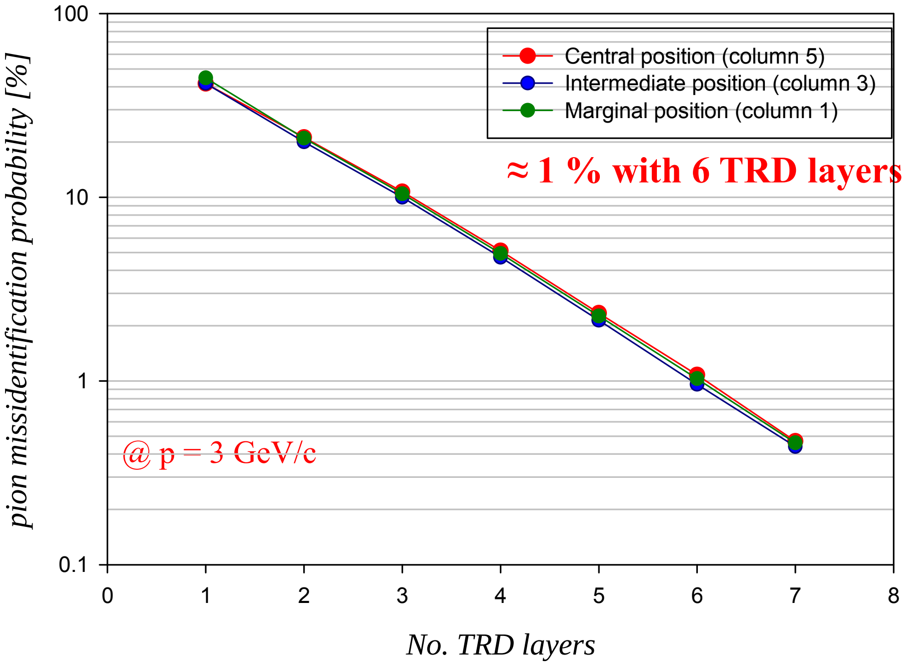




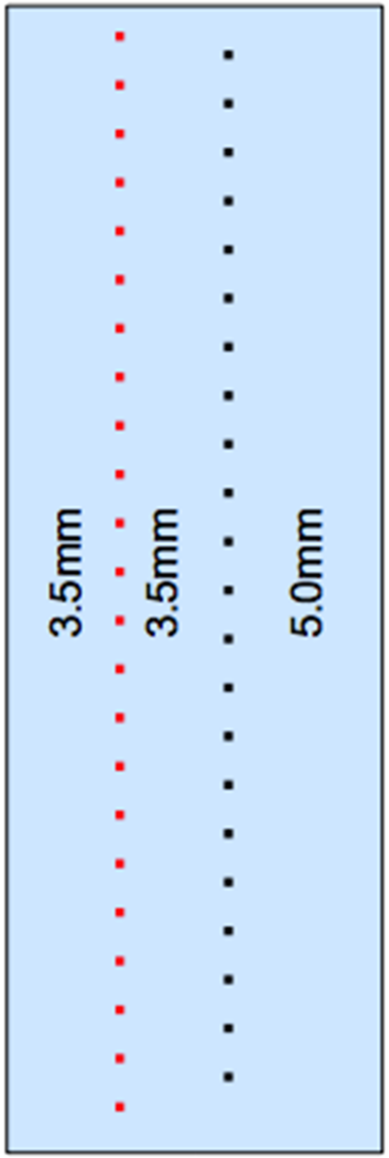
Pulse height distribution for electrons and pions:

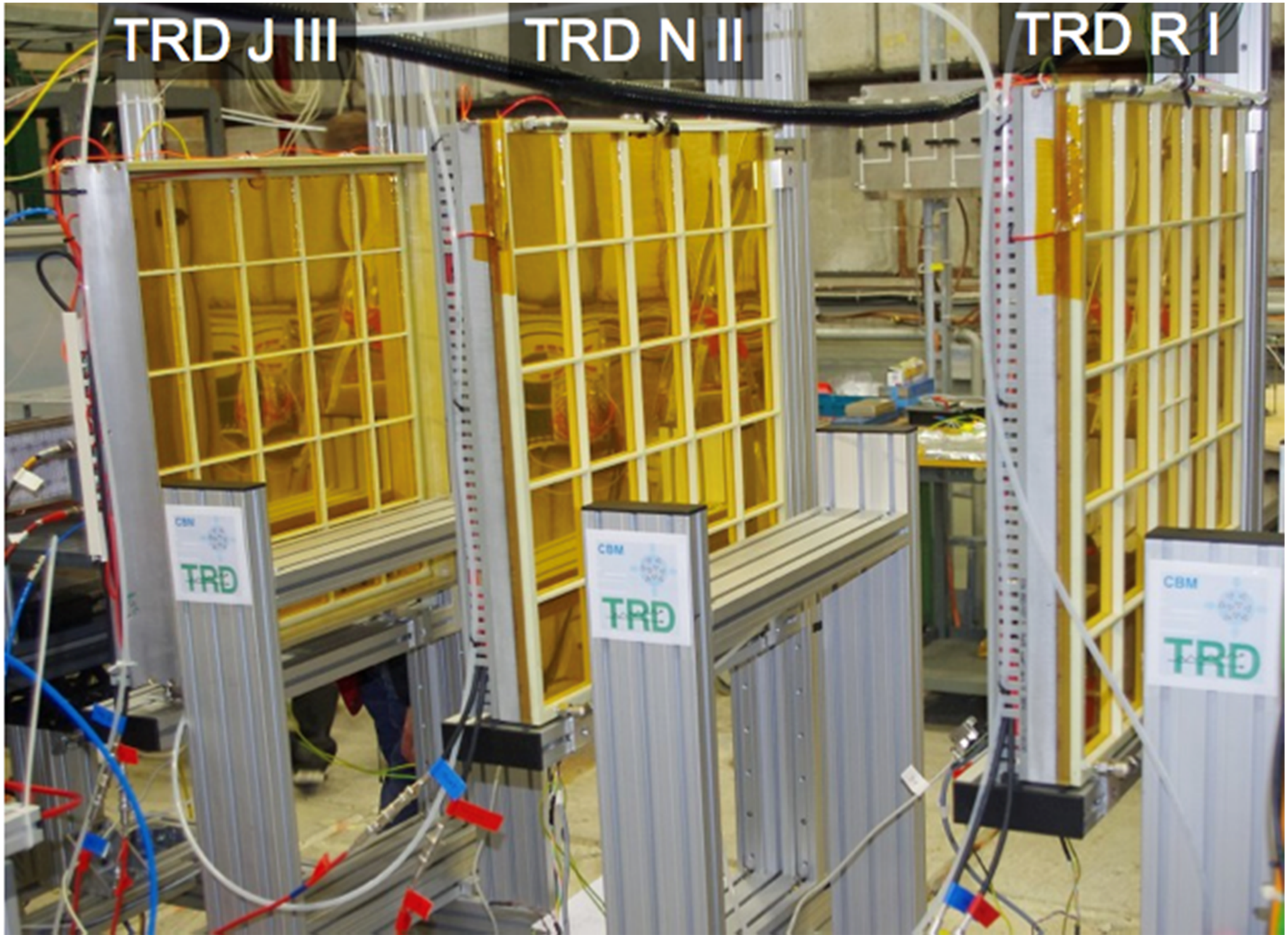


- Reg2
- HVa=2000V
- HVd=800V
- 3 GeV/c



Large area prototype - Muenster



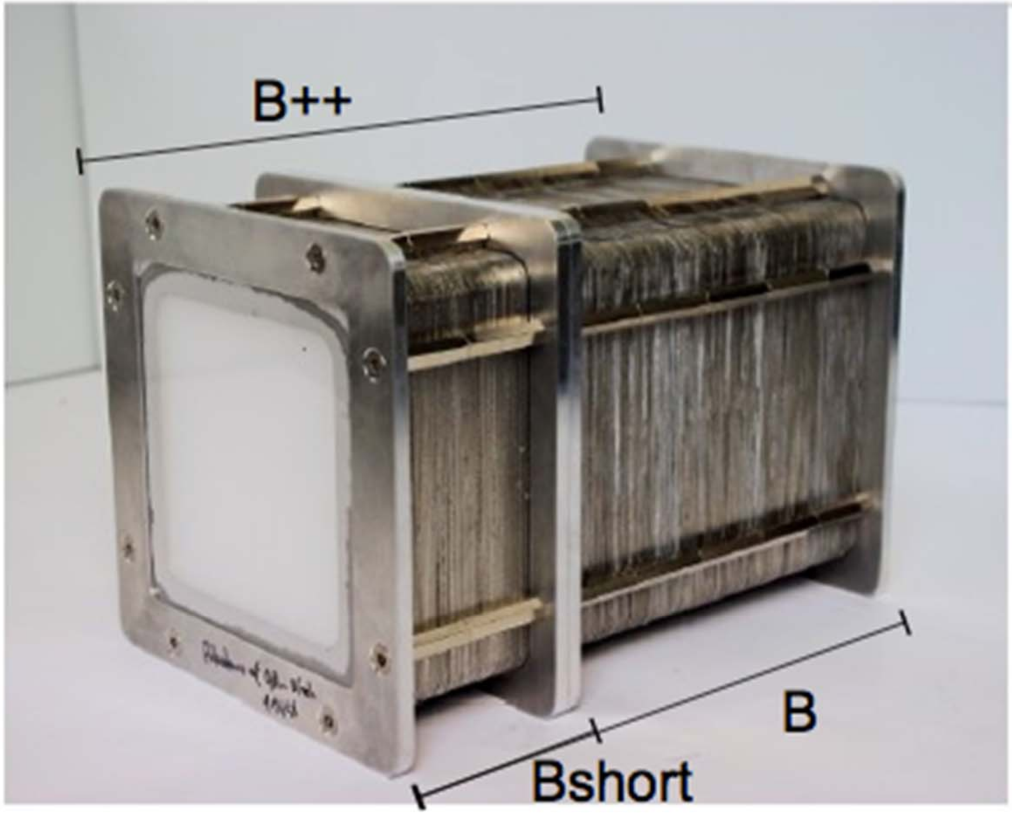


60x60 cm², 50μm aluminized Kapton entrance window

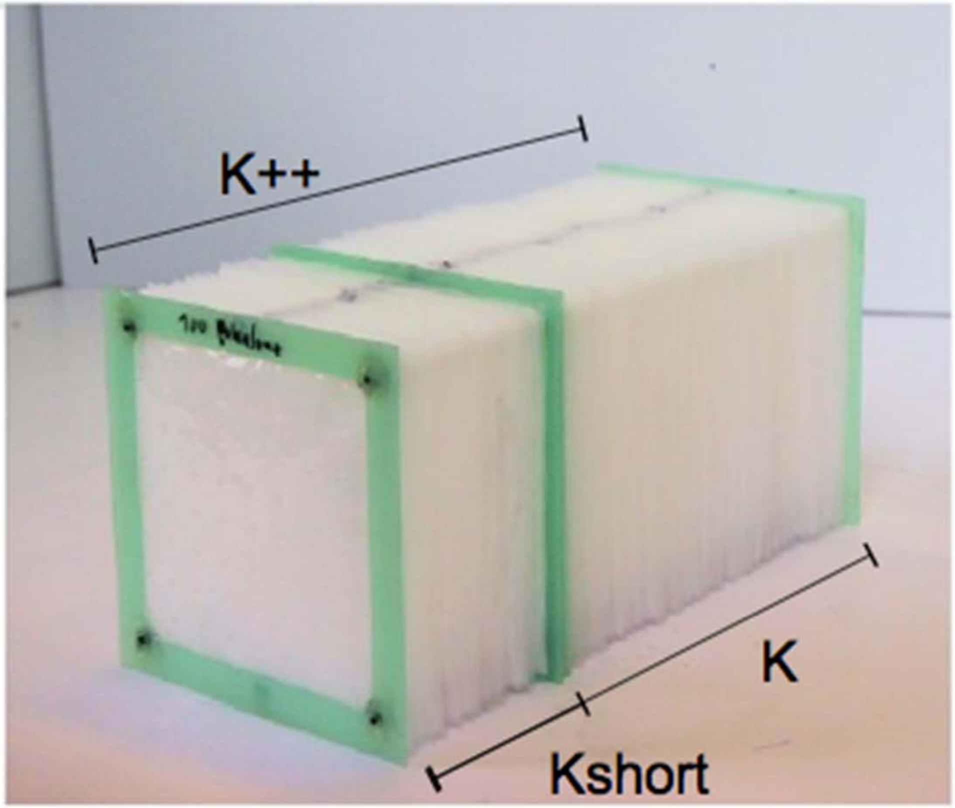
Low-Mass Radiator Development

Pokalon Radiators

Classical



micro-structured



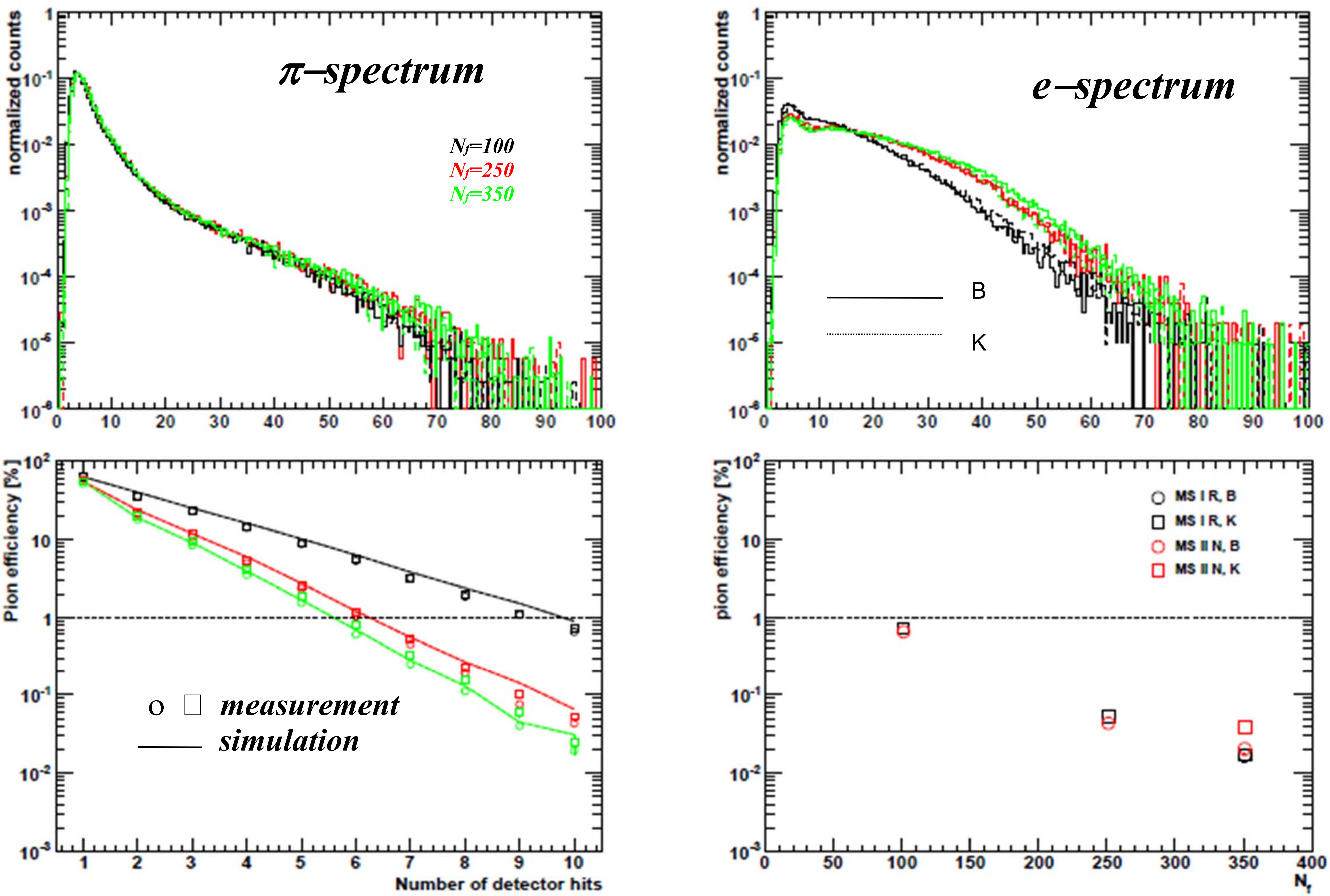
21.3 kg

0.176 kg

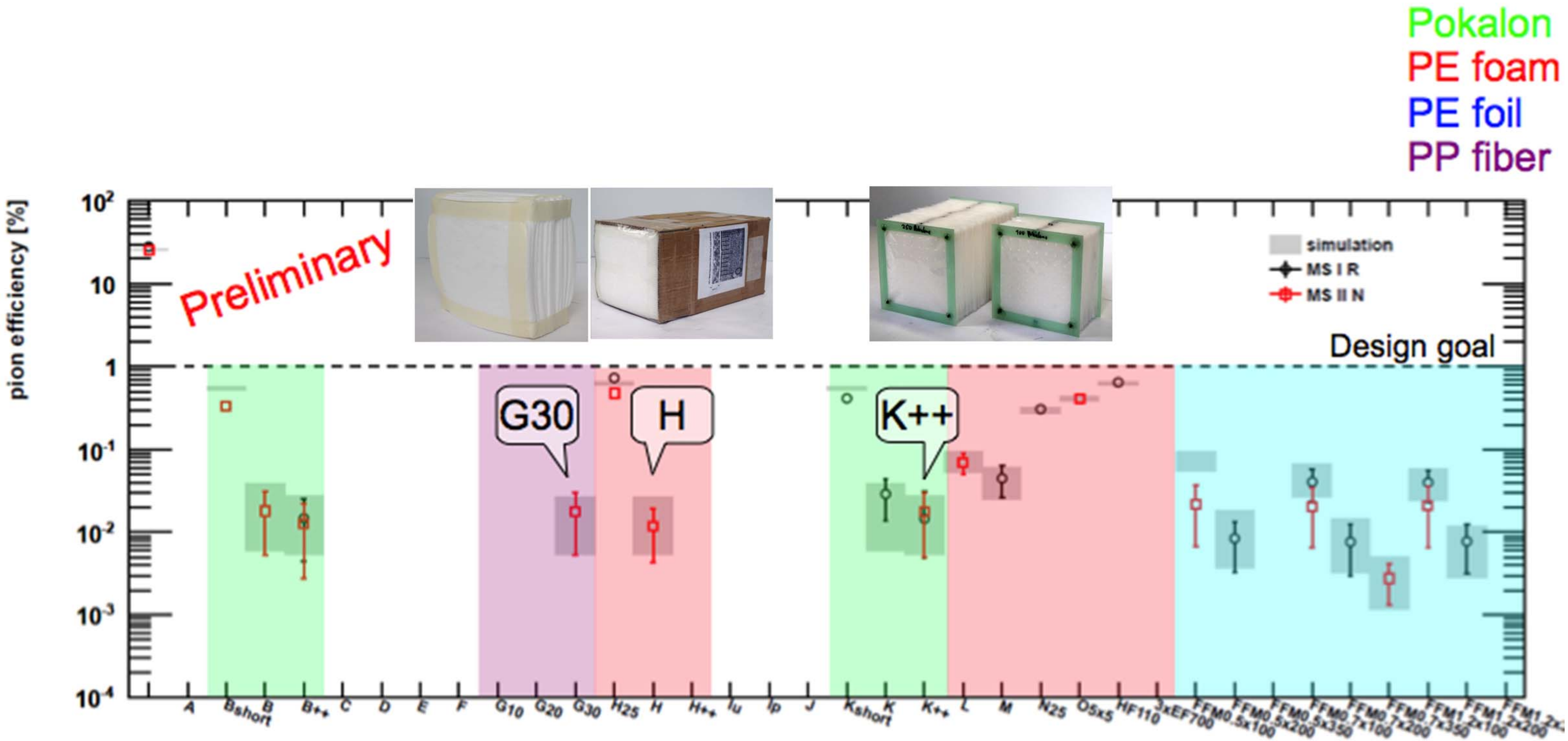
Stretched Pokalon *vs* *Embossed Self-Supporting Pokalon*

Low-Mass Radiator Development

π and e Spectra

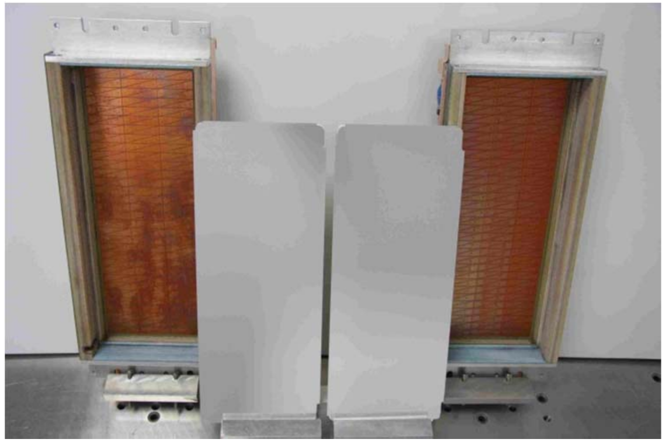
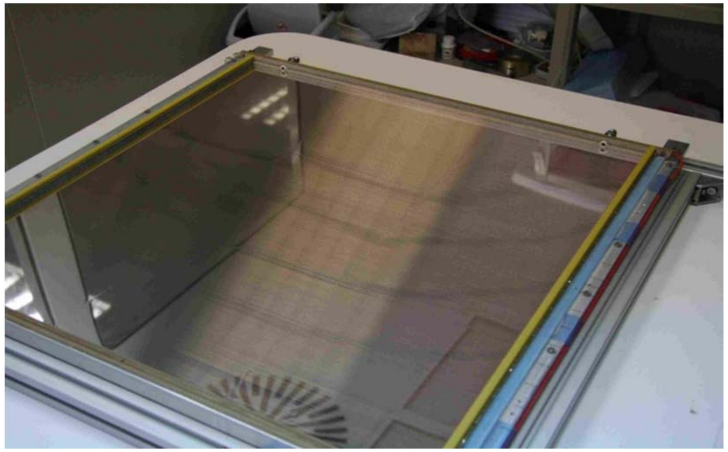


Systematic Radiator Studies - Muenster

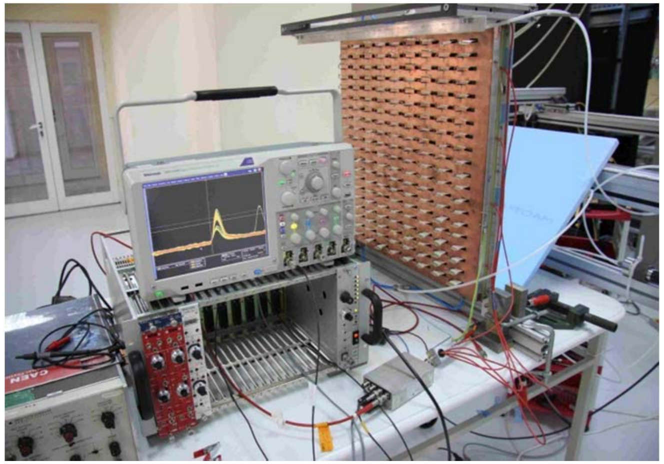
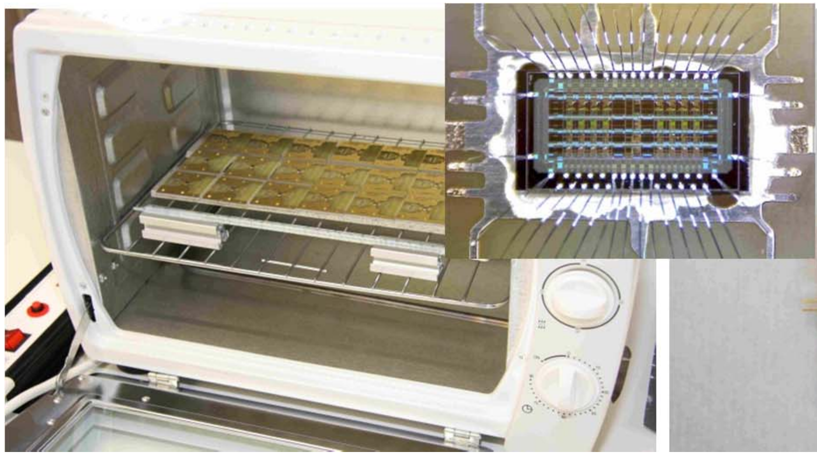
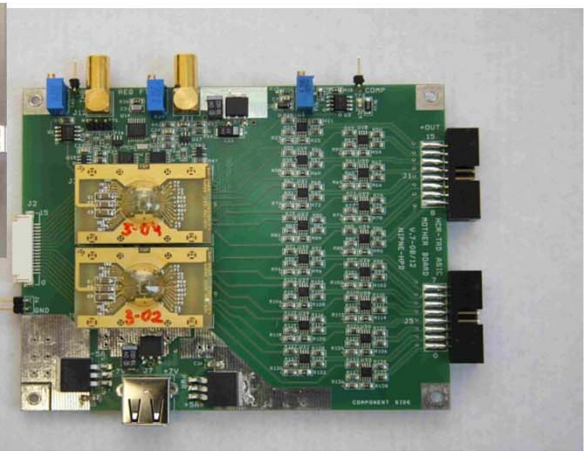
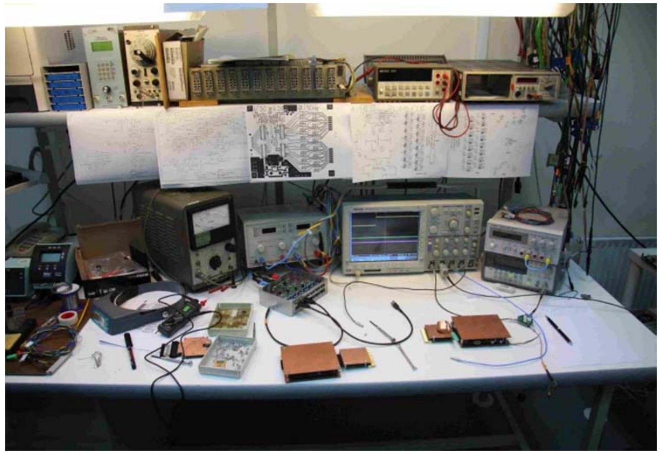


Approximated pion efficiency with 10 detector hits per track
@ 90% electron efficiency

The work behind the results



Two dimension position sensitive TRD Prototype

Double-sided TRD architecture (DSTRD)

- advantages:

Fast charge collection, good performance operated with 40 ns FASP ST
Very good electron-pion discrimination performance
Two dimensional position information
Counting rate performance up to 200 kHz/cm^2 (shown by previous measurements)

- drawbacks :

low geometric efficiency (~76%) for large area detector due to the signal extraction in the same plane with the readout electrode and the side placement of the signal connectors

Single-sided TRD architecture (SSTRD)

- advantages:

Allows larger active area ->higher geometric efficiency
Still good electron-pion discrimination performance for operation with 40 ns FASP ST
Two dimensional position information

- drawbacks :

Slower charge collection
- an increase of ST to 80-100 ns is expected to improve the e/pi discrimination for a 6 TRD layer configuration
Counting rate performance not yet tested

In order to maximize the geometric efficiency, the SSTRD is considered as basic cell for CBM-TRD detector

Publications

M. Petris et al., "*Two-dimensional position sensitive transition radiation detector*", Nucl. Instr. and Meth. A 714 (2013), 17

M. Petris et al., "*TRD Detector Development for the CBM Experiment*", Submitted to Proceedings (Nucl. Instr. and Meth. A) of the Vienna Conference on Instrumentation 2013

Conferences

M. Tarzila et al., " *e/π identification and position resolution of high granularity single sided TRD prototype*", 2nd European Nuclear Physics Conference - EuNPC, 16-21 September 2012 Bucharest

M. Petris et al., "*TRD Detector Development for CBM Experiment*", 13th Vienna Conference on Instrumentation, 11 – 15 February 2013

CBM Meetings

M. Petrovici et al., "*Garfield and CADENCE simulations. New TRD prototype for 2012 in-beam tests. Low polar angles TRD architecture*", 19thCBM Collaboration Meeting, GSI Darmstadt, 26-30 March 2012 GSI, Darmstadt

M. Tarzila et al., "*Results of TRD prototypes operated using FASP*", 19th CBM Collaboration Meeting, GSI Darmstadt, 26-30 March 2012 GSI, Darmstadt

M. Tarzila et al., " *e/π rejection performance and systematic studies of position resolution of Bucharest TRD prototype* ", 20th CBM Collaboration Meeting, Kolkata, India, 24 - 28 September, 2012

M. Tarzila et al., "*Bucharest 2012 TRD prototype - in-beam test results*", 21th CBM Collaboration Meeting, GSI Darmstadt, 8-12 April 2013 GSI, Darmstadt

V. Catanescu, "*General characteristics of FASP version 2*", 21th CBM Collaboration Meeting, GSI Darmstadt, 8-12 April 2013 GSI, Darmstadt

CBM Progress Reports

M. Petris et al., "*Single-sided TRD prototype*", CBM Progress Report 2011, GSI Darmstadt (2012), p.46

M. Petris et al., "*High granularity single-sided TRD prototype*", CBM Progress Report 2011, GSI Darmstadt (2012), p.47

M. Petris et al., "e/π *identification and position resolution of double-sided TRDs*", CBM Progress Report 2011, GSI Darmstadt (2012), p.48

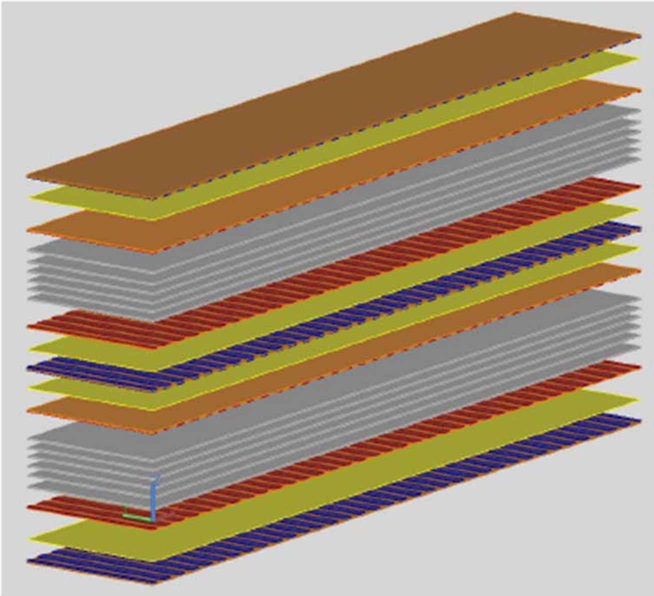
F.Constantin and M. Petcu, "*Free running mode acquisition for a high counting rate TRD*", CBM Progress Report 2011, GSI Darmstadt (2012), p.53

F.Constantin, "*FPGA-based free running mode acquisition for a high counting rate TRD*", CBM Progress Report 2012, GSI Darmstadt (2013), p.56

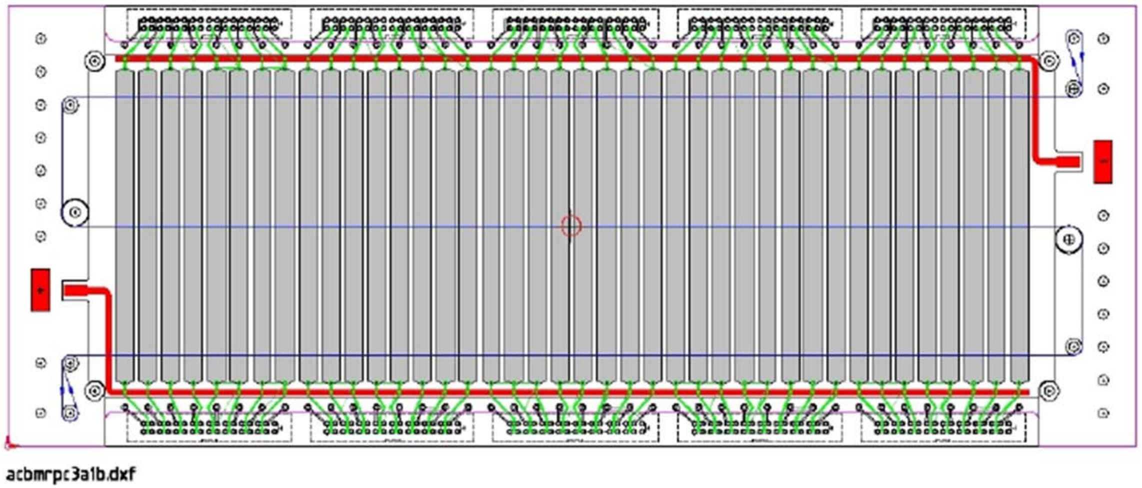
M. Tarzila et al., "*Two dimensionally position sensitive real size CBM-TRD prototype*", CBM Progress Report 2012, GSI Darmstadt (2013), p.60

M. Petris et al., "e/π *identification and position resolution of a high granularity TRD prototype based on a MWPC*", CBM Progress Report 2012, GSI Darmstadt (2013), p.61

RPC
Narrow strips electrode



Readout electrode



7.1 mm strip pitch = 5.6mm width + 1.5 mm gap

Symmetric two stack structure: 2 x 5 gas gaps

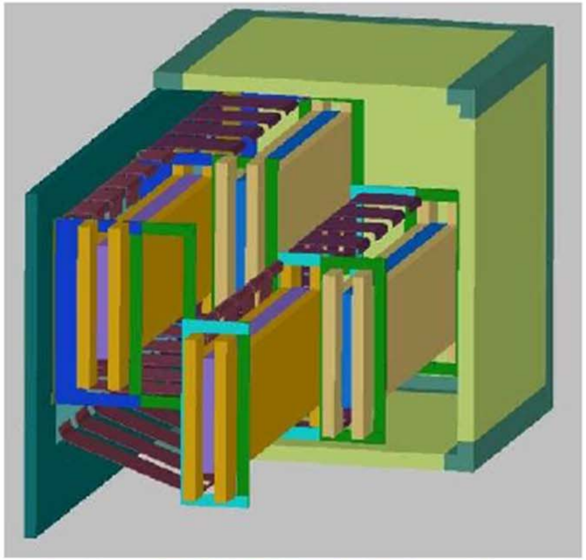
Differential readout

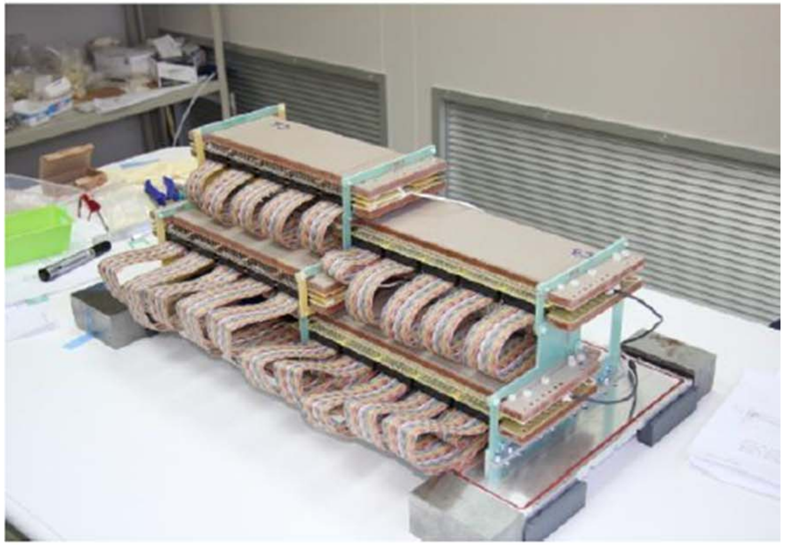
Active area: 96 x 300 mm²

Electrodes: 0.7 mm low resistivity Chinese glass

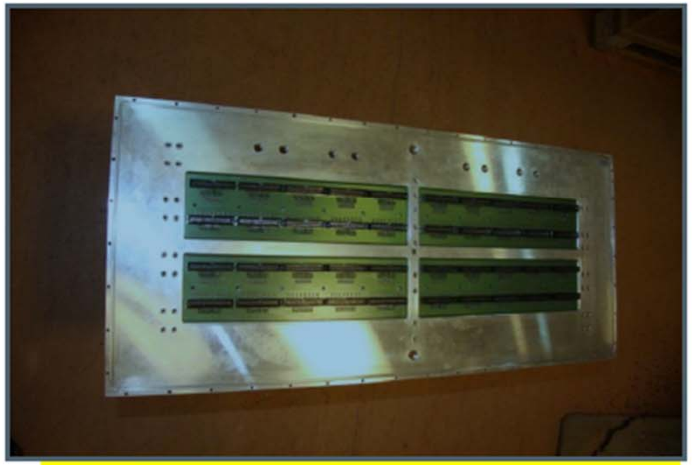
Gap size: 140 µm thickness

MRPC module design





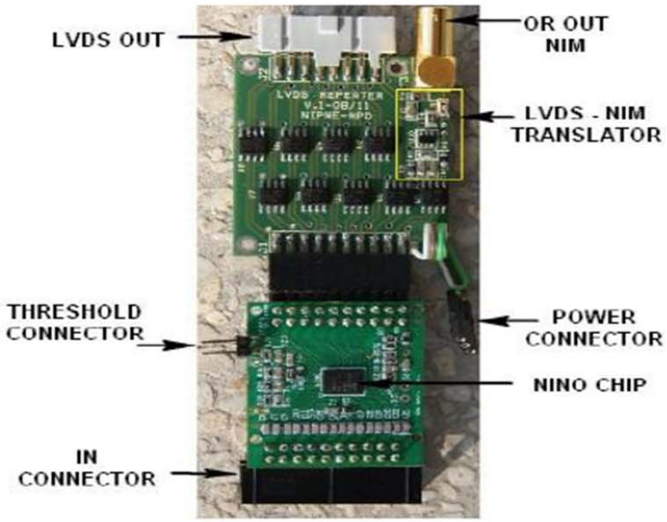
Gas box: 10 mm honeycomb sheet sandwiched between two 0.4 mm stesalit plates plated on inner side by a pcb of 0.13 mm copper layer

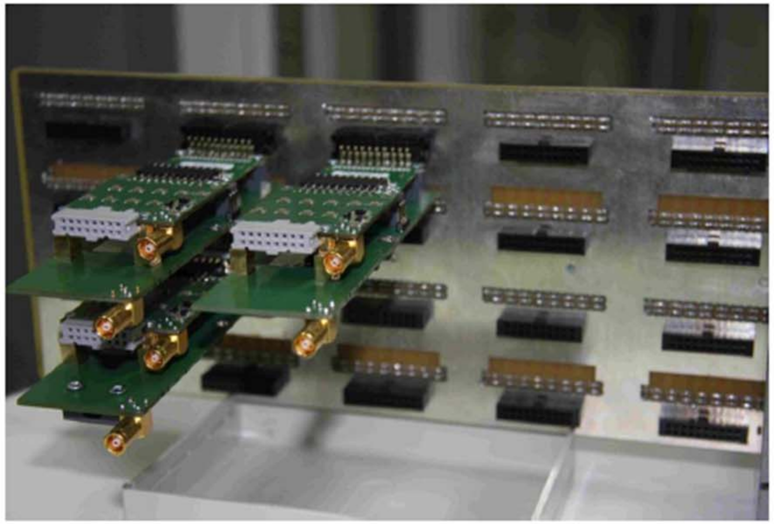


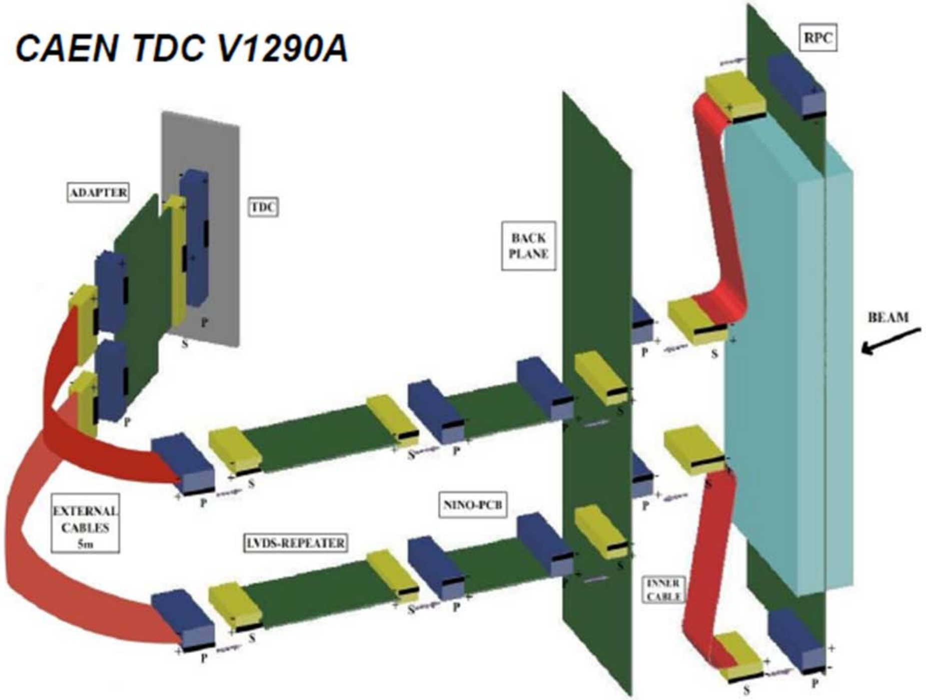
Back Flange: 12 mm Al thickness; support the whole inner structure

Staggered design to avoid efficiency leaks and providing intrinsic coincidence measurement

FEE based on NINO fast amplifier & discriminator

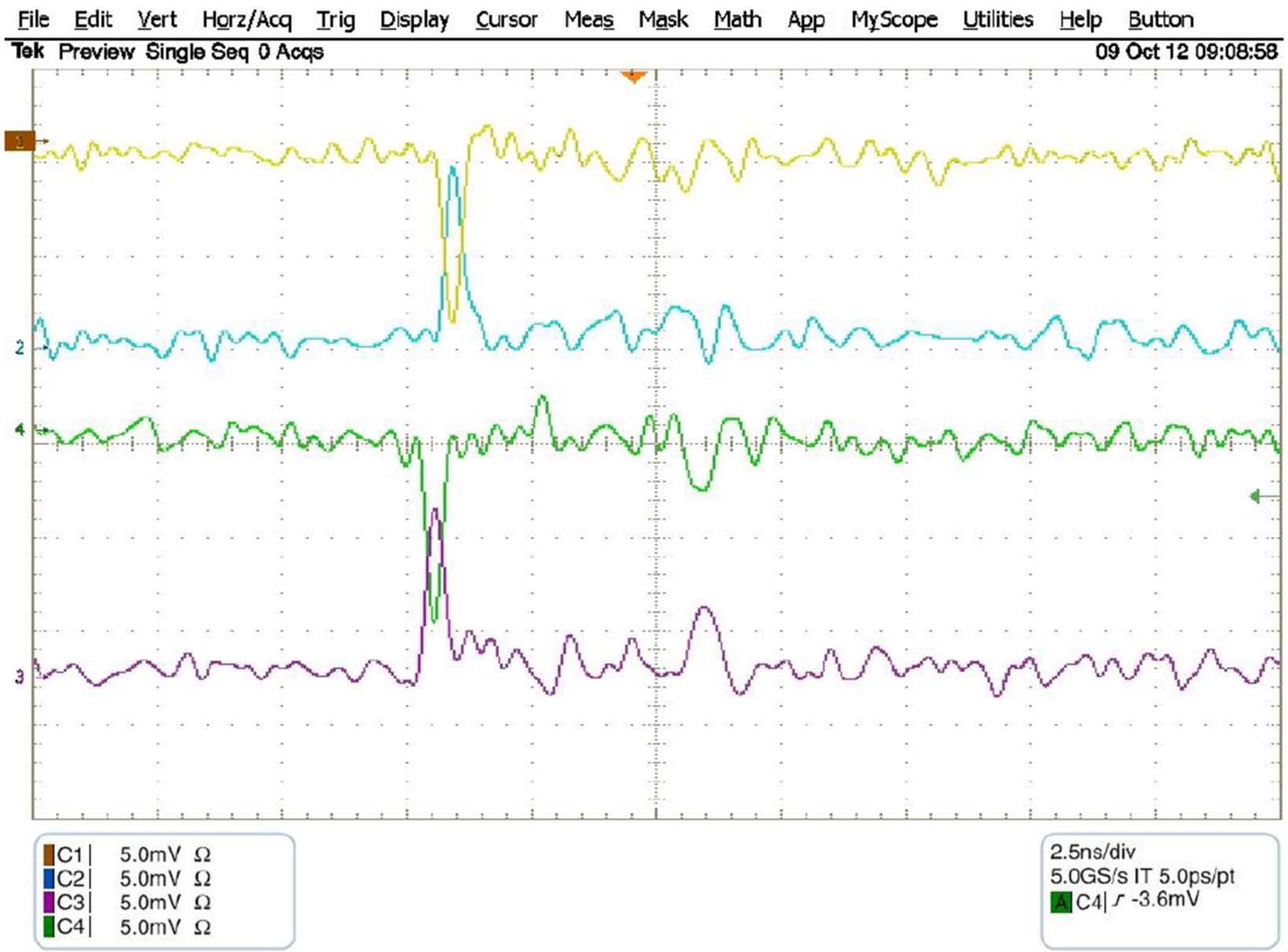




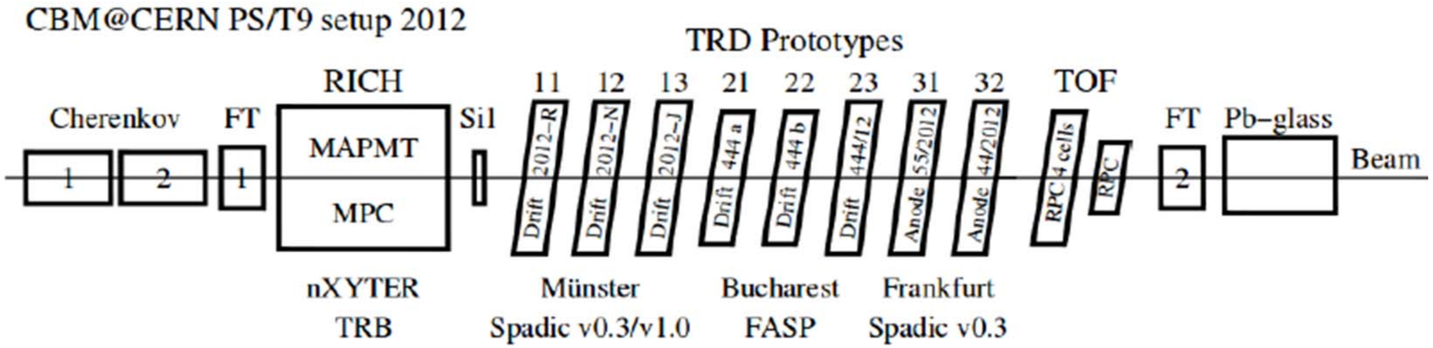


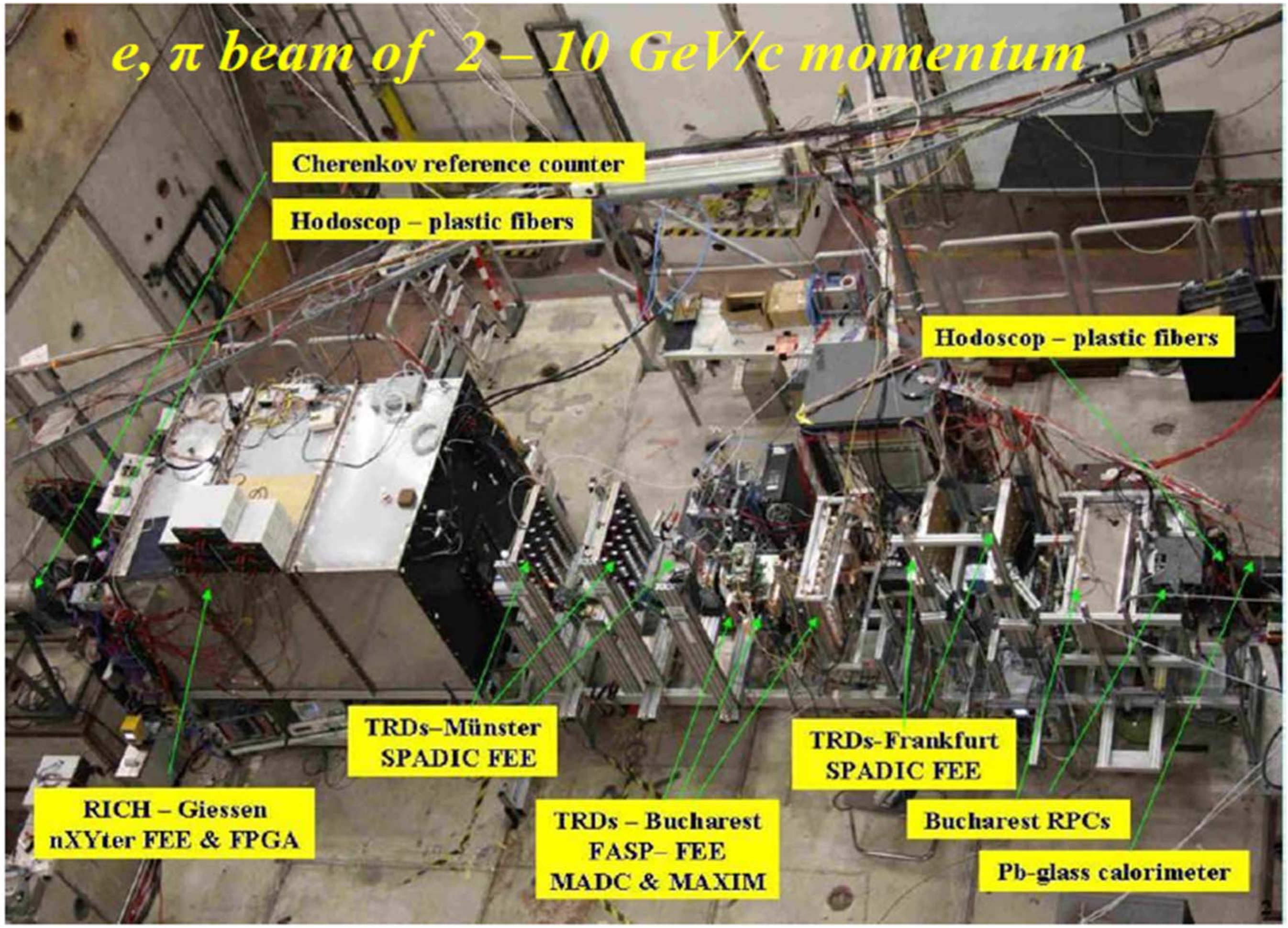
MRPC Lab tests

Signal shape with Co – source:

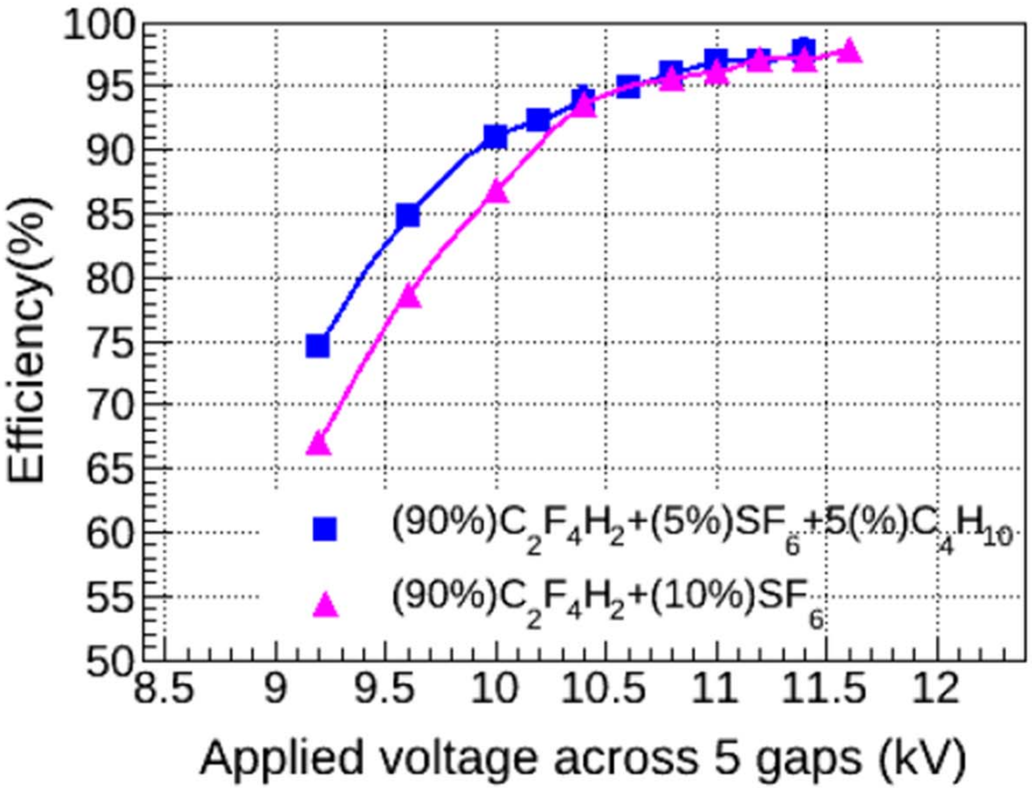


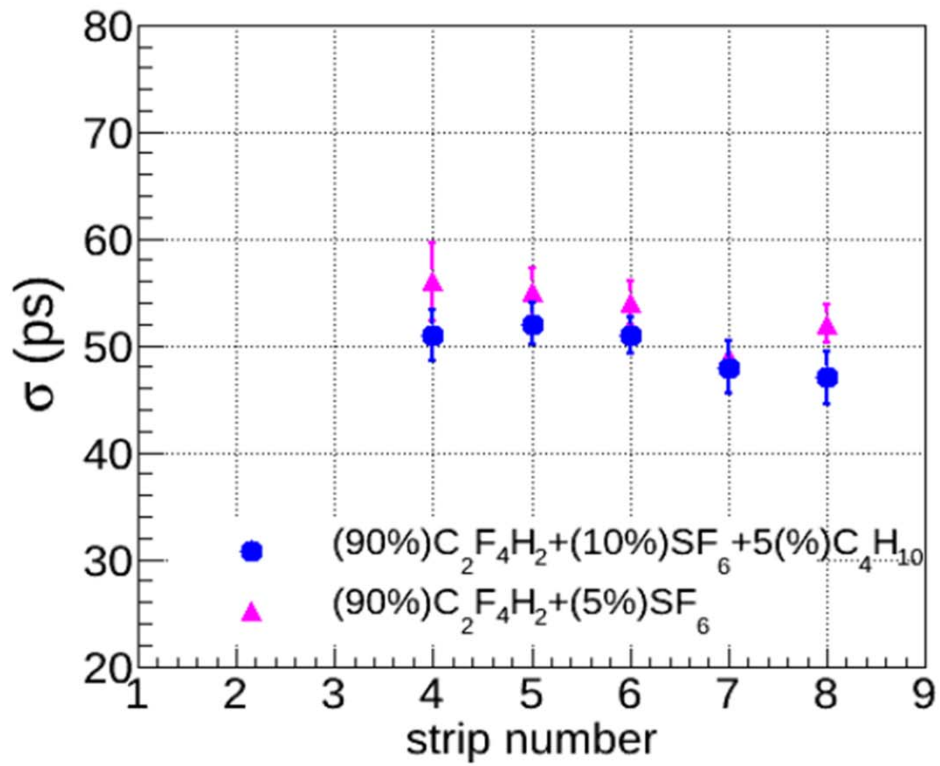
MRPC beam test at CERN





Efficiency and time resolution

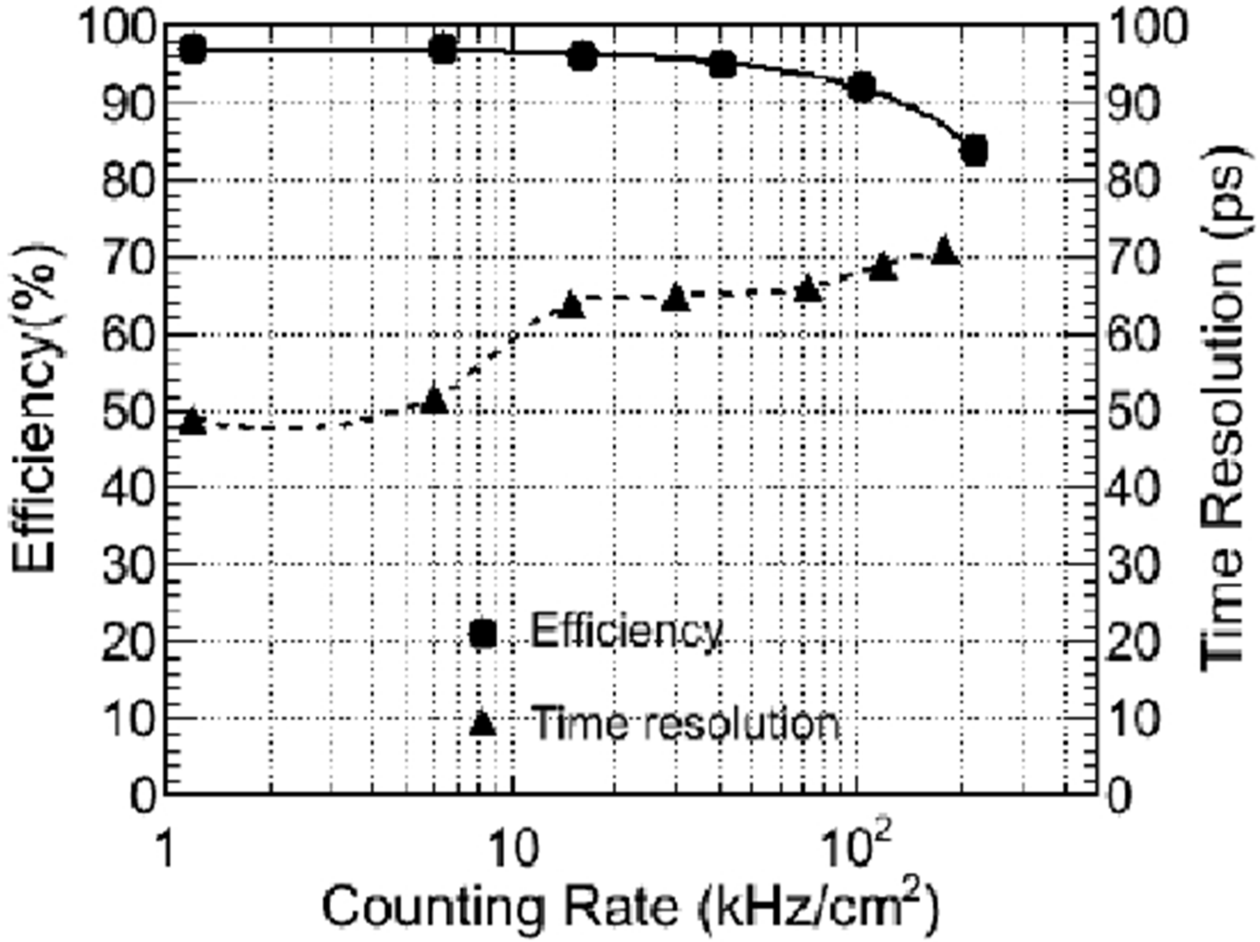




Slight dependence on gas mixture

Rate capability

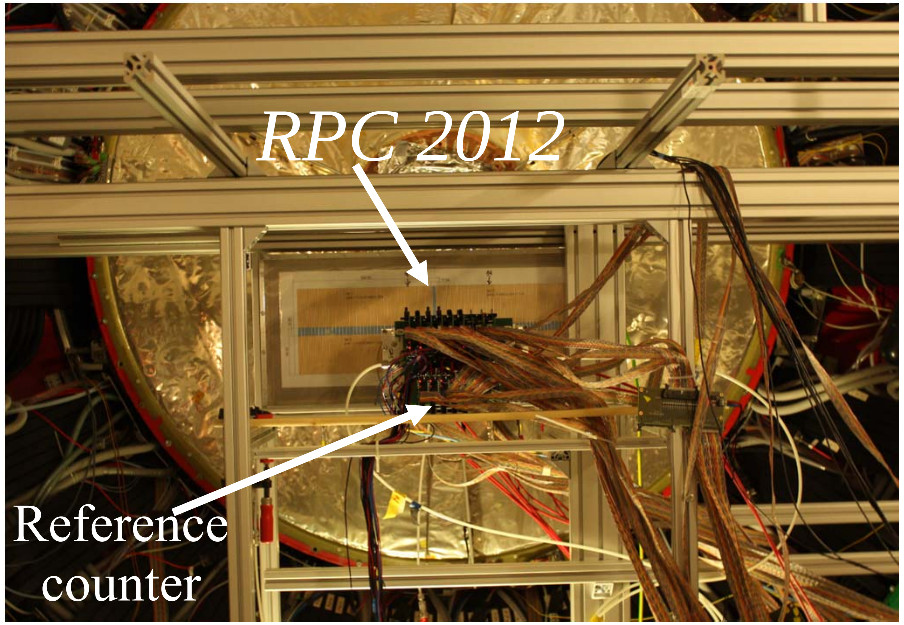
From COSY test



Counter fulfills CBM requirements in terms of rate capability and resolution!

System performance

In-beam test setup @ GSI Oct. 2012

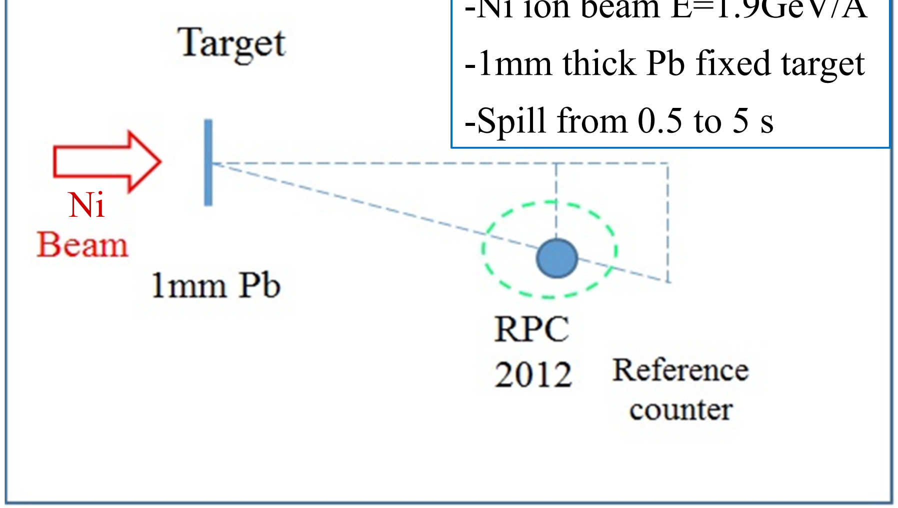


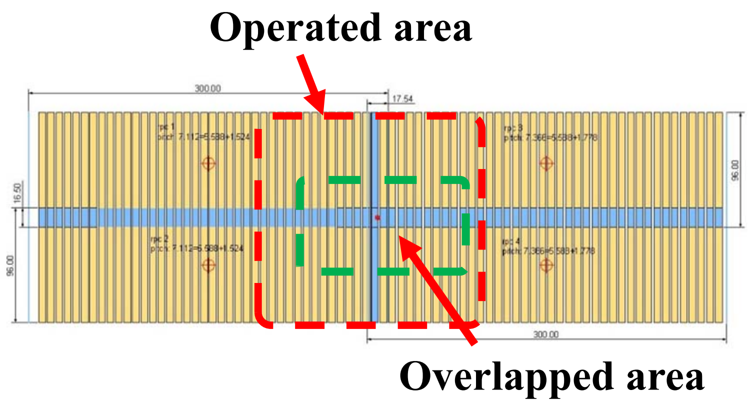
Beam parameters

-Ni ion beam E=1.9GeV/A

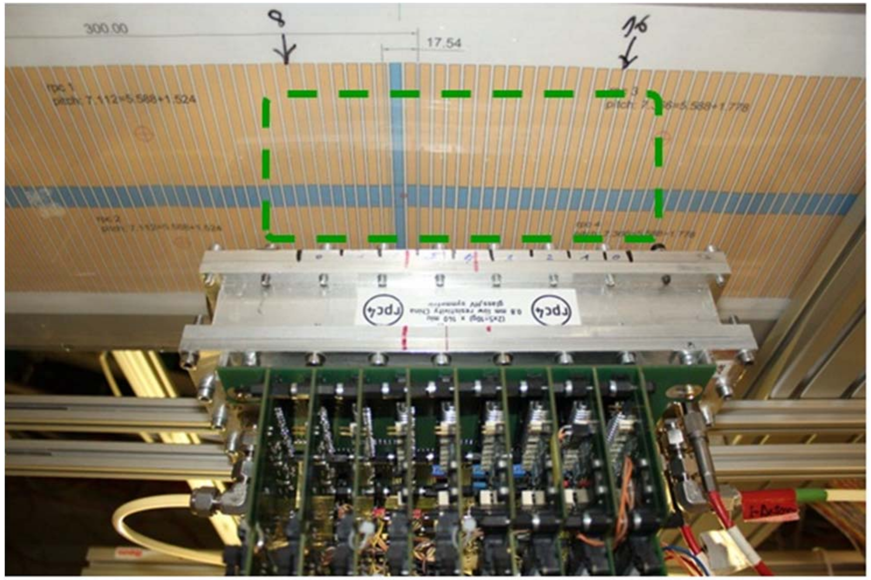
-1mm thick Pb fixed target

-Spill from 0.5 to 5 s





System performance



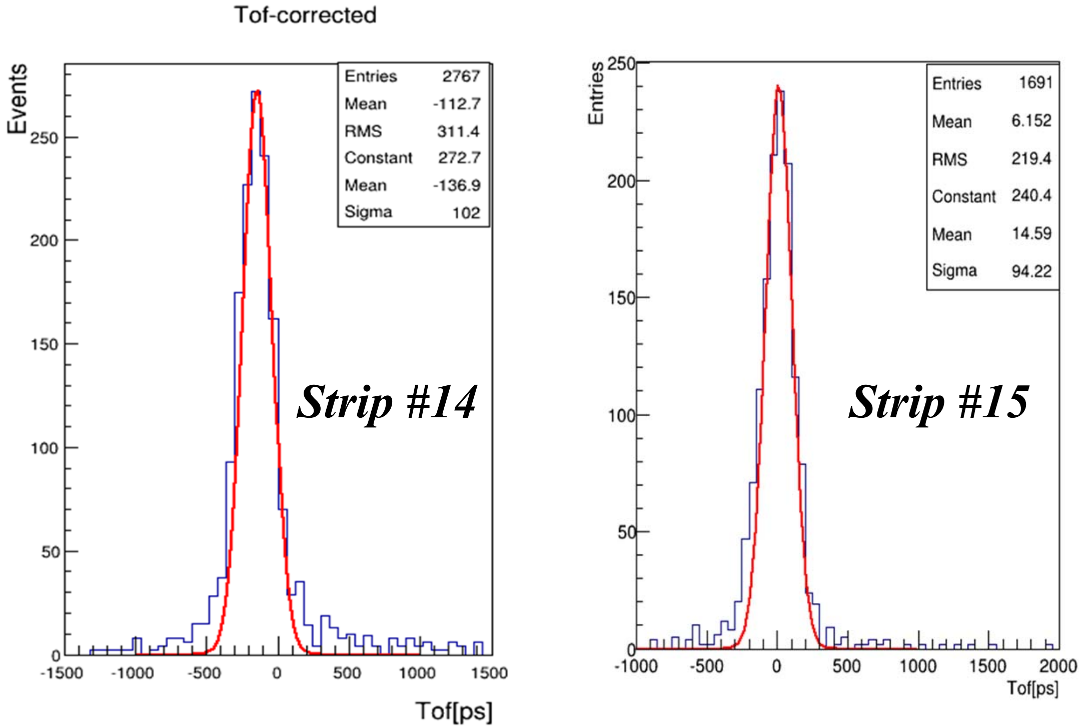
- *2012 4 cell RPC prototype*
- *Narrow strip RPC reference counter (M.Petrovici et al. JINST 7 P11003)*
    - *2 x 5 gaps (140 μm/gap)*
    - *0.7 mm low resistivity Chinese glass*
    - *2.54 mm strip pitch*
    - *HV electrodes: strips in contact with the outermost glass plate*

FEE: RPC 2012-> NINO

Reference counter: PADI

Conversion -> FPGA TDC

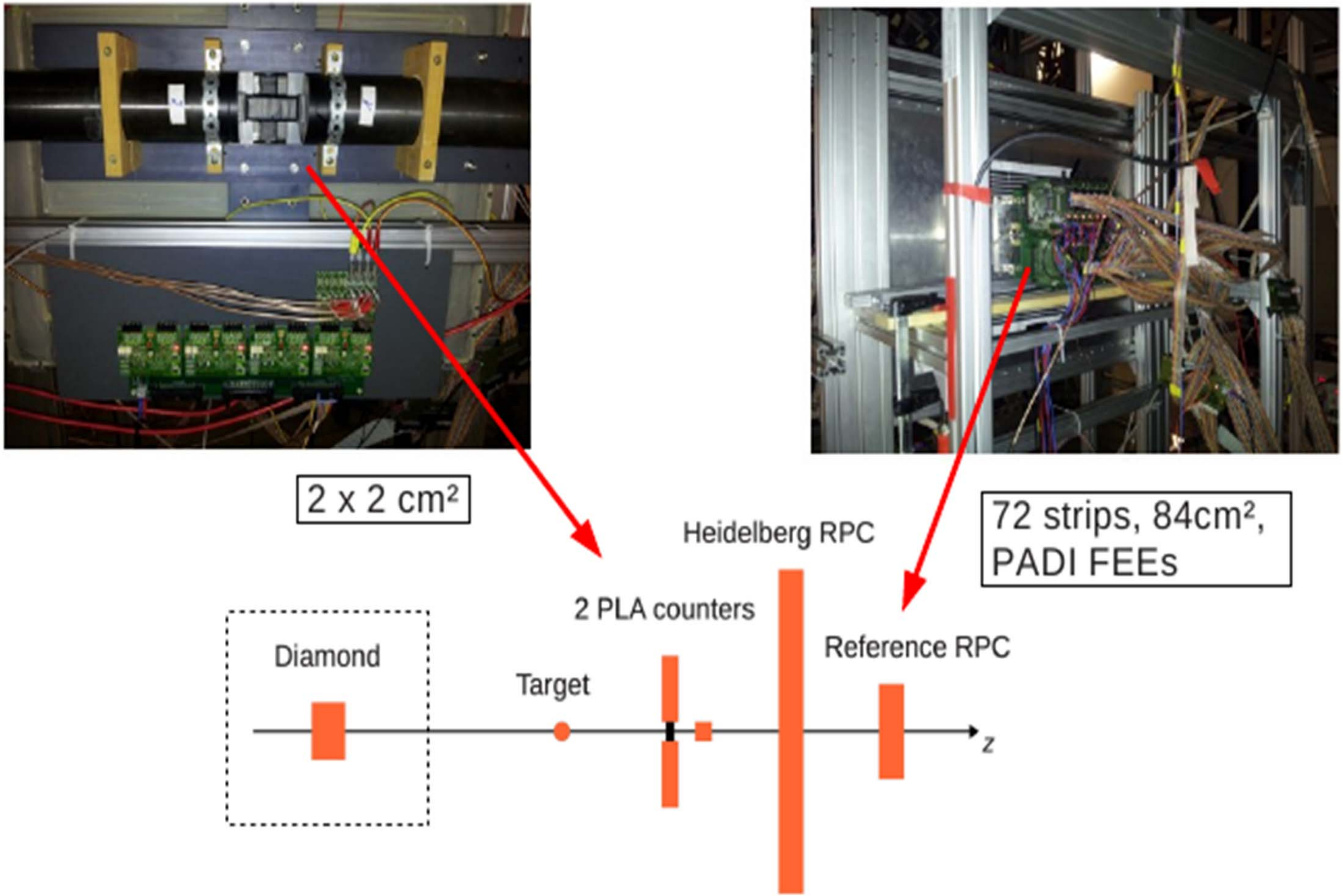
$$dt = \left(t^{up} + t^{dw}\right)^{rpc1}/2 - \left(t^{up} + t^{dw}\right)^{rpc2}/2$$



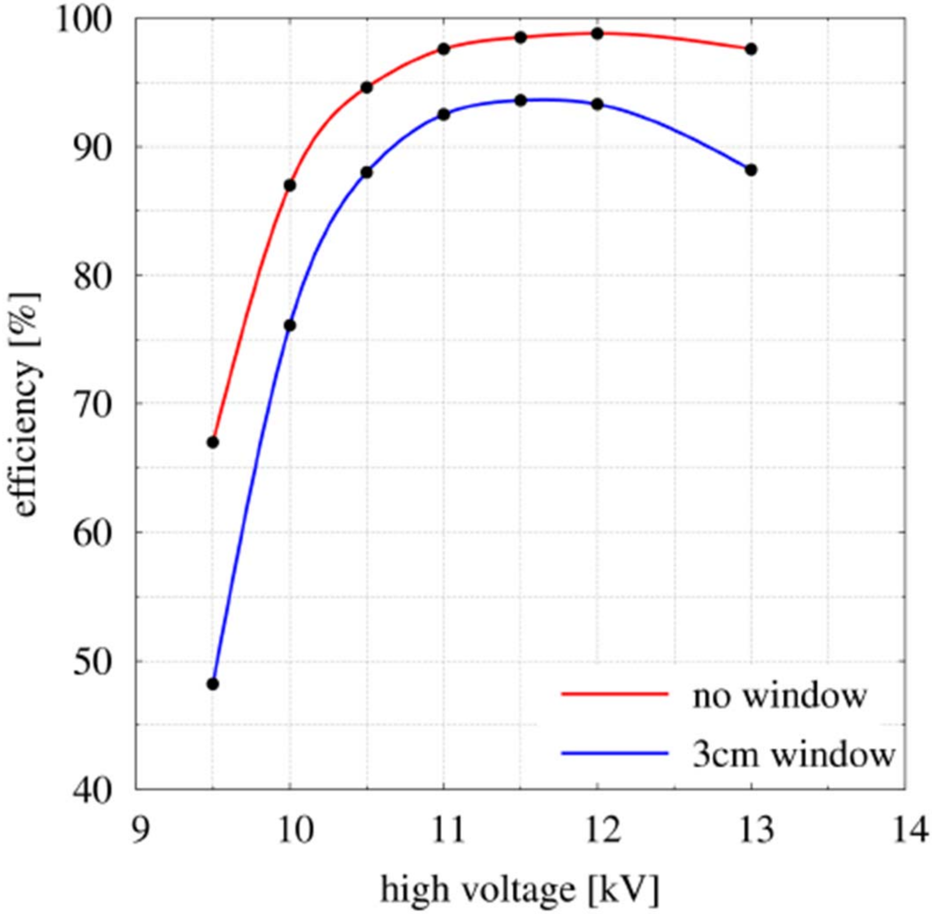
~ 18 kHz/cm²

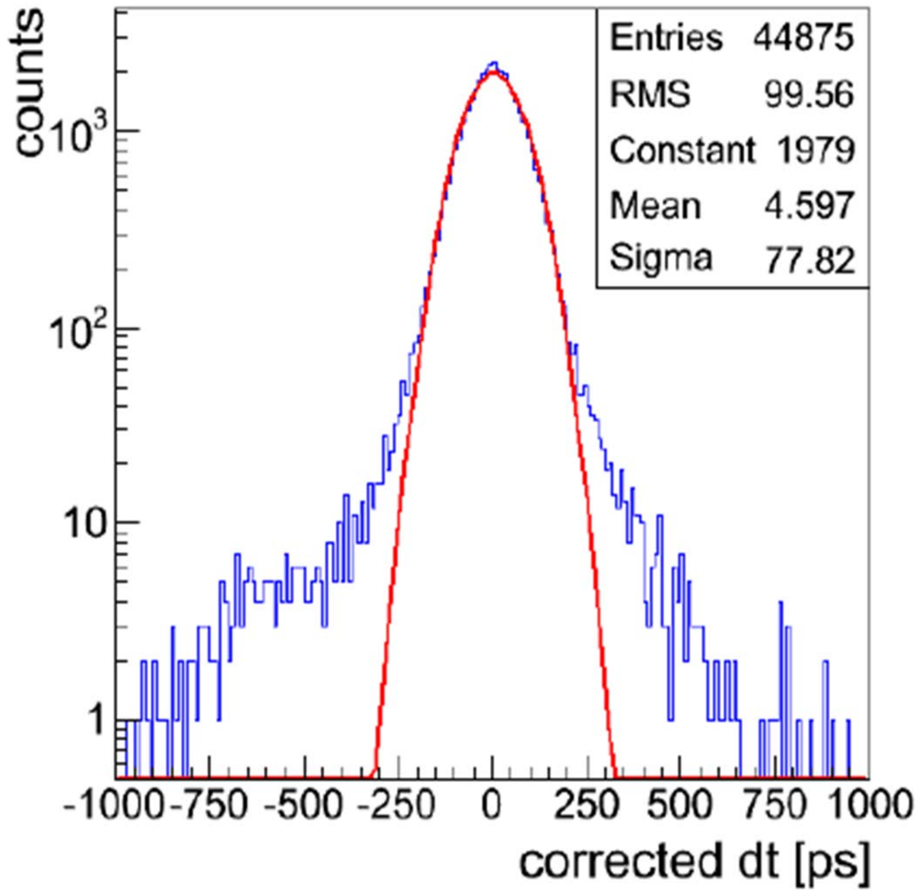
Work in progress ...

Wide strip RPC - Heidelberg



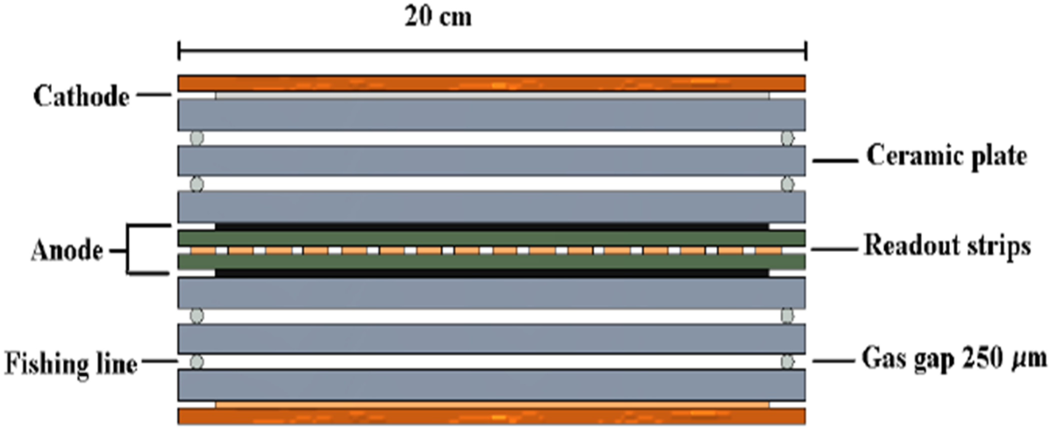
Wide strip RPC - Heidelberg

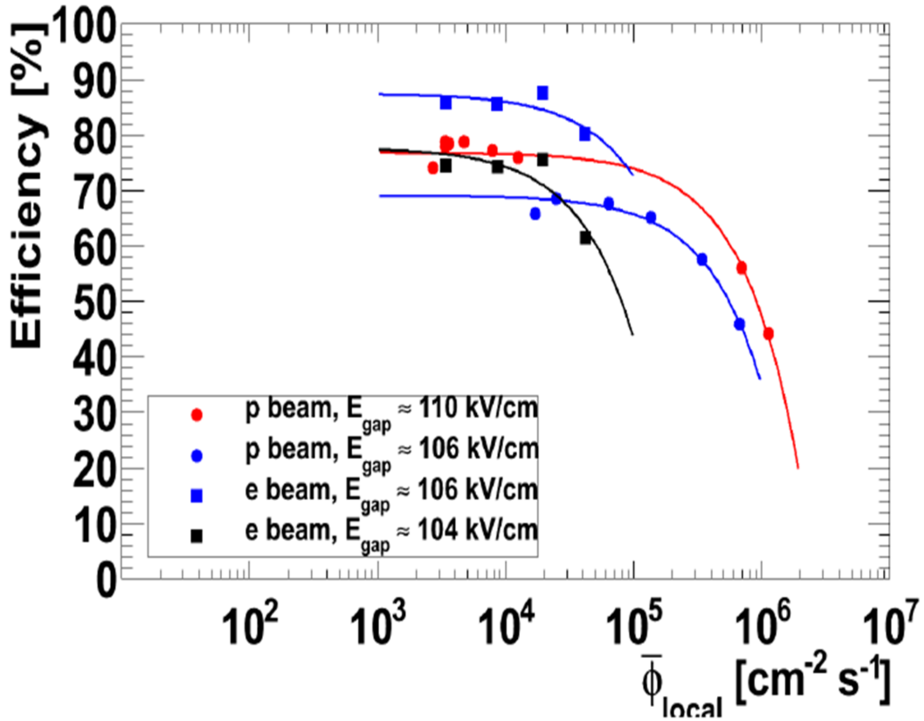




Work in progress ...

Ceramic RPC - Rossendorf

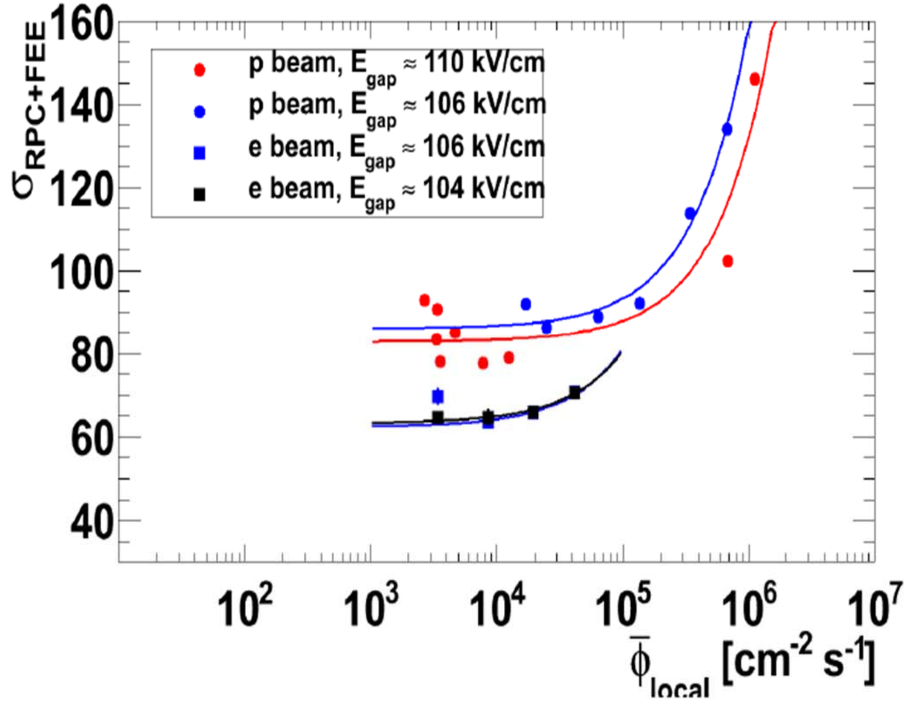




20x20 cm^2 prototype

- $\rho \sim 5{\cdot}10^9\ \Omega$ cm, d = 2 mm
- four gaps of 250 μm
- fishing line

gas mixture 85% $C_2H_2F_4$ + 10 % SF_6 + 5 % iC_4H_{10}



Publications

M. Petris et al., "*Toward a high granularity and high counting rate, differential readout timing MRPC* ", Nucl. Instr. and Meth. A 661, Suppl.1(2012), S129

M. Petrovici et al., *High counting rate, two-dimensional position sensitive timing RPC,* Journal of Instrumentation Volume 7 November 2012 (JINST 7 P11003),

Conferences

M. Petrovici et al., "*High counting rate, differential, strip readout, multi-gap, timing RPC",* XI Workshop on Resistive Plate Chambers and Related Detectors, 5-10 February 2012, Frascati, Italy

M. Petris et al., "*Performance of high granularity, high counting rate, differential strip readout MRPC for CBM-TOF* ", 2nd European Nuclear Physics Conference - EuNPC, 16-21 September 2012, Bucharest, Romania

L. Radulescu et al.,*" Determination of the most efficient structure of CBM TOF inner zone based on small size detection cells using 3D design techniques",* 2nd European Nuclear Physics Conference - EuNPC, 16-21 September 2012, Bucharest, Romania

CBM Meetings

M. Petrovici et al., "*Planning towards the Inner CBM-TOF wall"* , 19thCBM Collaboration Meeting, GSI Darmstadt, 26-30 March 2012 GSI, Darmstadt

M. Petris et al., "*Status of high rate glass MRPC with differential strip readout*", 19th CBM Collaboration Meeting, GSI Darmstadt, 26-30 March 2012 GSI, Darmstadt

M. Petris et al., "S*tatus of high rate MRPC with differential narrow strips readout and ToF wall inner zone design"* 20th CBM Collaboration Meeting, Kolkata, India, 24 - 28 September, 2012

M. Petris et al., "*In-beam test results of basic RPC structure of the inner zone of CBM-TOF wall. Update of the inner wall design*", 21th CBM Collaboration Meeting, GSI Darmstadt, 8-12 April 2013 GSI, Darmstadt

CBM Progress Reports

M. Petris et al., "*Time and position resolution for high granularity, multigap, symmetric, dierential readout - timing RPC* ", CBM Progress Report 2011, GSI Darmstadt (2012), p.55

M. Petris et al., "*Towards a real size RPC cell for CBM RPC-TOF*", CBM Progress Report 2011, GSI Darmstadt (2012), p.56

M. Petris et al., "*Toward a RPC basic structure for the inner zone of CBM RPC-TOF wall*", CBM Progress Report 2012, GSI Darmstadt (2013), p.68

"The only way to make progress is to defy one of those prohibitions that are uncritically accepted without good reasons"

M. Gell-Mann

Conference in Honour of Murray Gell-Mann's 80th Birthday

Try to avoid such a sequence!