Proiectarea, realizarea si testarea in fascicul de electroni si pioni a unui prototip de detector TRD tip camera multifilara cuplata cu o zona de drift cu electrod de citire a semnalelor cu granularitatea ceruta de zona interna a primei statii a sub-detectorului CBM-TRD.

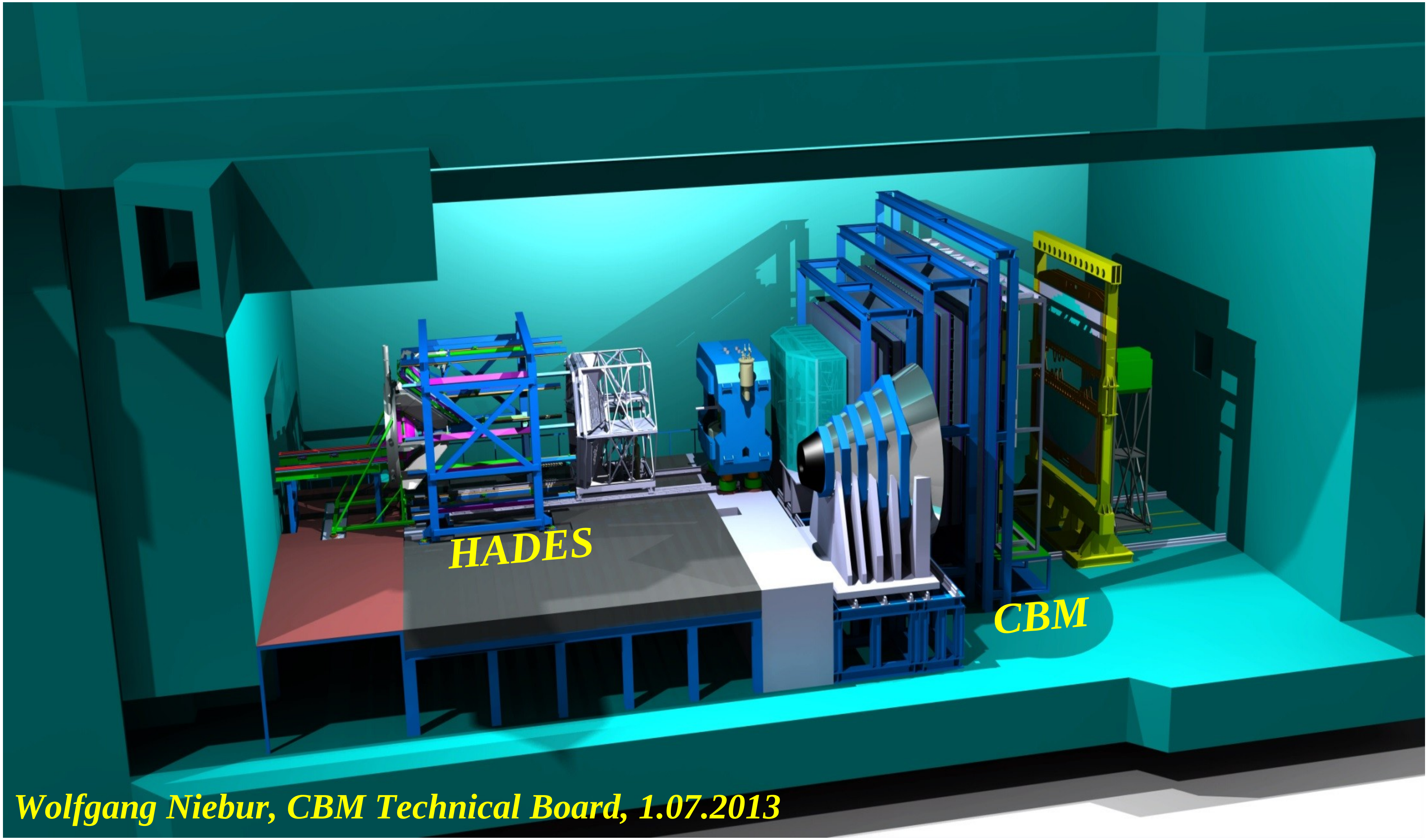
Simulari CADENCE pentru optimizarea parametrilor chip-ului ASIC FASP in scopul imbunatatirii procesarii semnalului furnizat de prototipul de detector TRD

Proiect NUCLEU PN 09 37 01 03

Mariana Petris, Seminar DFH, 12.07.2013

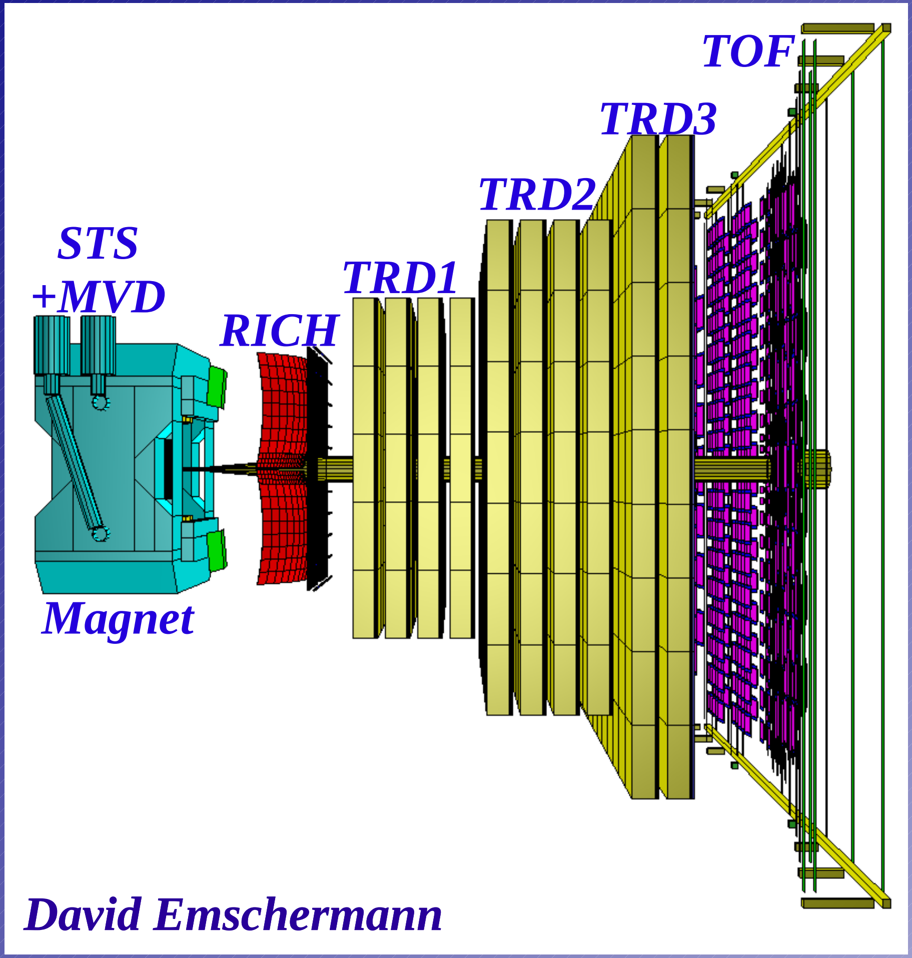
CBM experimental set-up

- ***next generation fixed target experiments***
- ***systematic exploration of QCD phase diagram in the region of high baryon densities in A+A collisions from 2 – 45 (35) A·GeV beam energy***

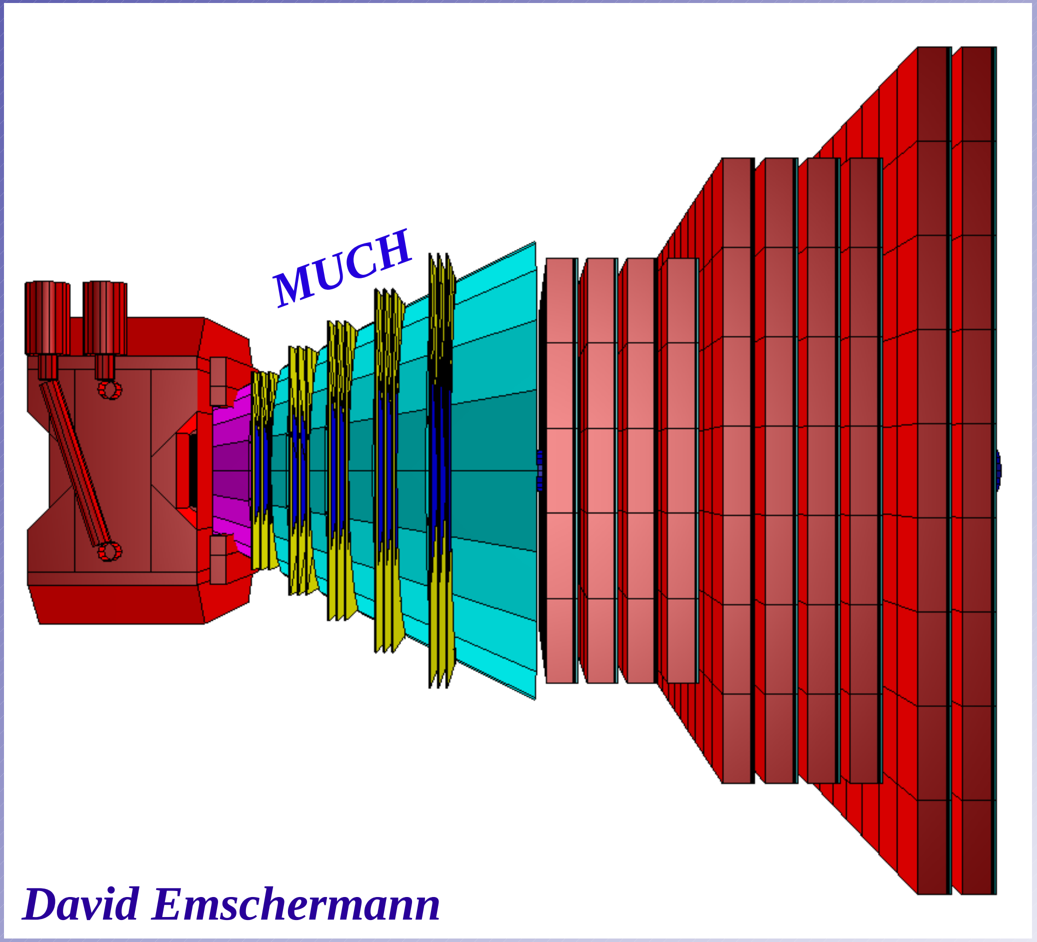


SIS300 – Current geometry of the CBM-TRD subsystem

3 station (TRD1, TRD2, TRD3) , 10 layers

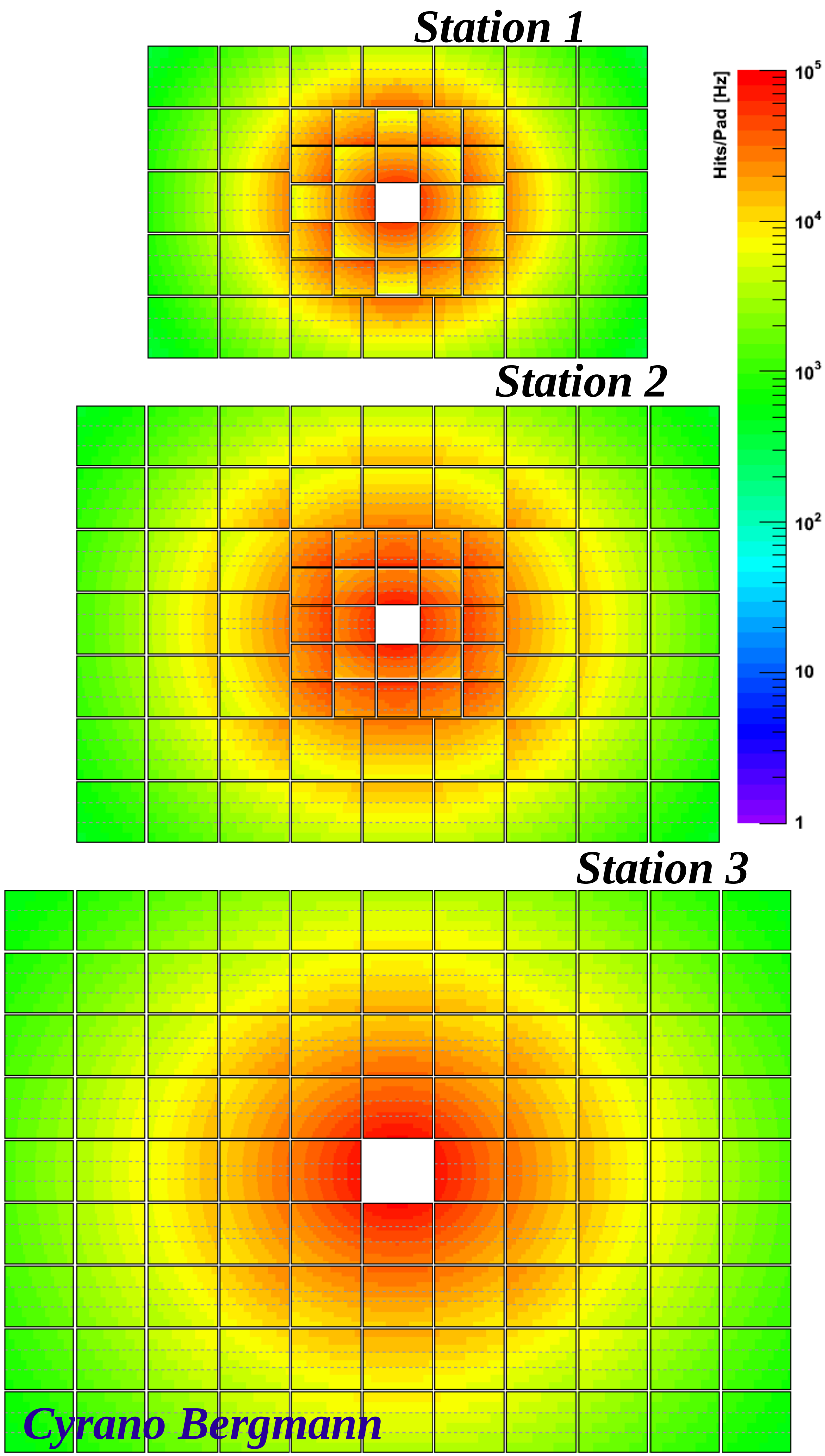


Experimental setup with the electron identification system



Experimental setup with the muon identification system

CBM-TRD requirements



- ***Electron identification:***

- 100 pion suppression factor @ 90% electron efficiency

- ***Tracking all charged particles:***

Position resolution: ~200 – 300 µm

Inner zone have to cope with:

- high counting rate up to 100 kHz/cm²

- high multiplicity

Prototypes for the inner zone:

- develop fast signals

- thick gas layer for efficient TR absorption

- high channel granularity

- high geometrical efficiency

Prototype Solution:

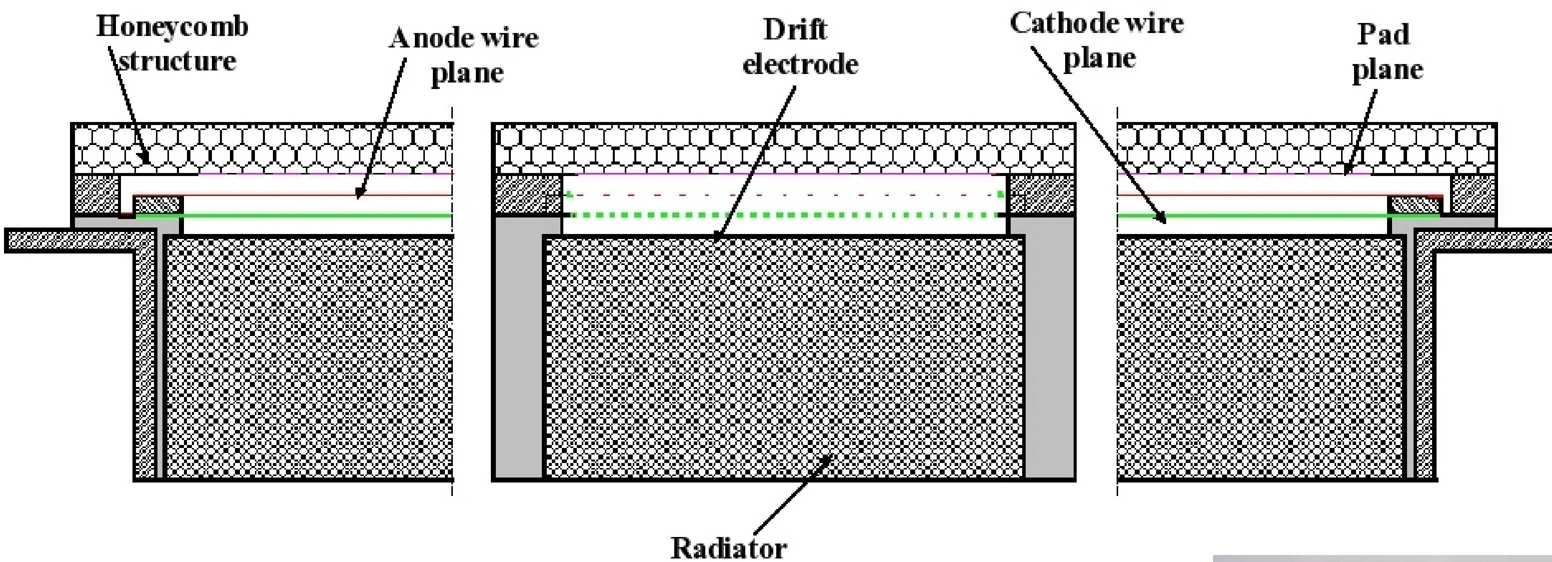
- MWPC + short drift region: 2 x 4 mm + 4 mm

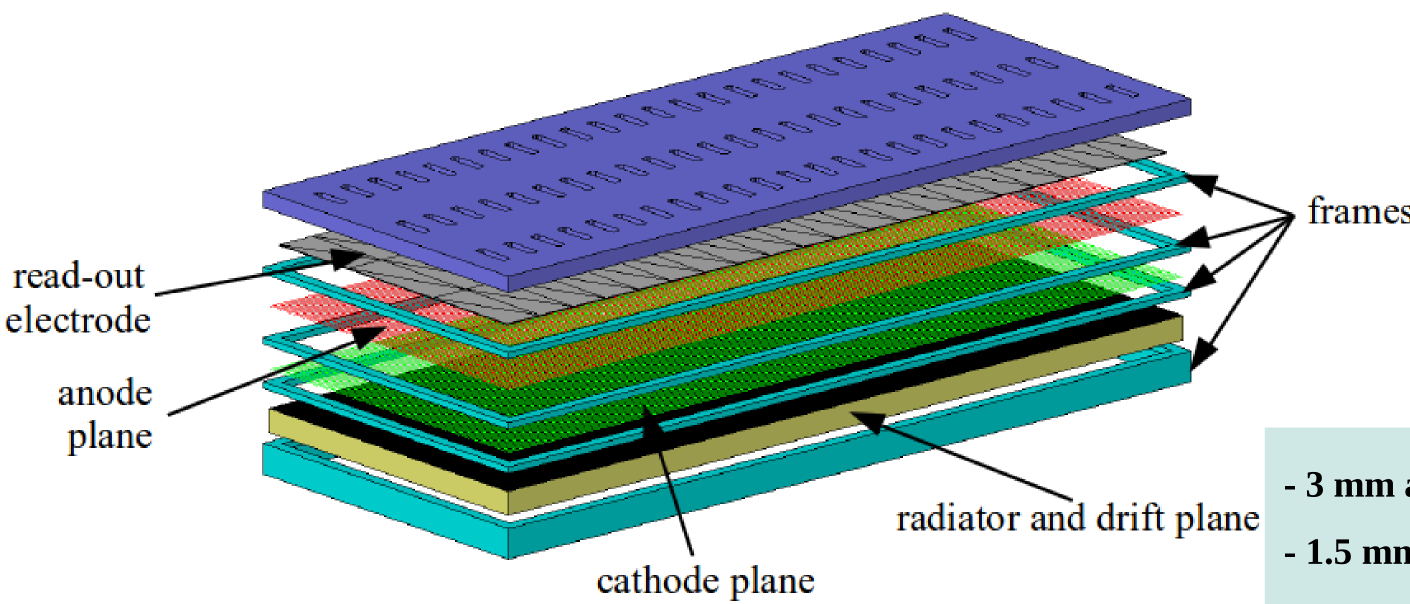
- 250 ns average drift time of electron clusters

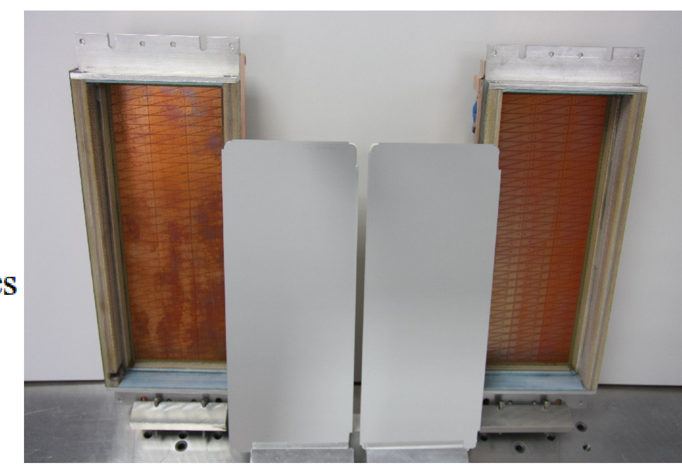
- 1 cm² readout cell area

Constructive details of the high granularity TRD prototype

Single MWPC (2x 4 mm amplification zone) +4 mm drift zone (DZ)

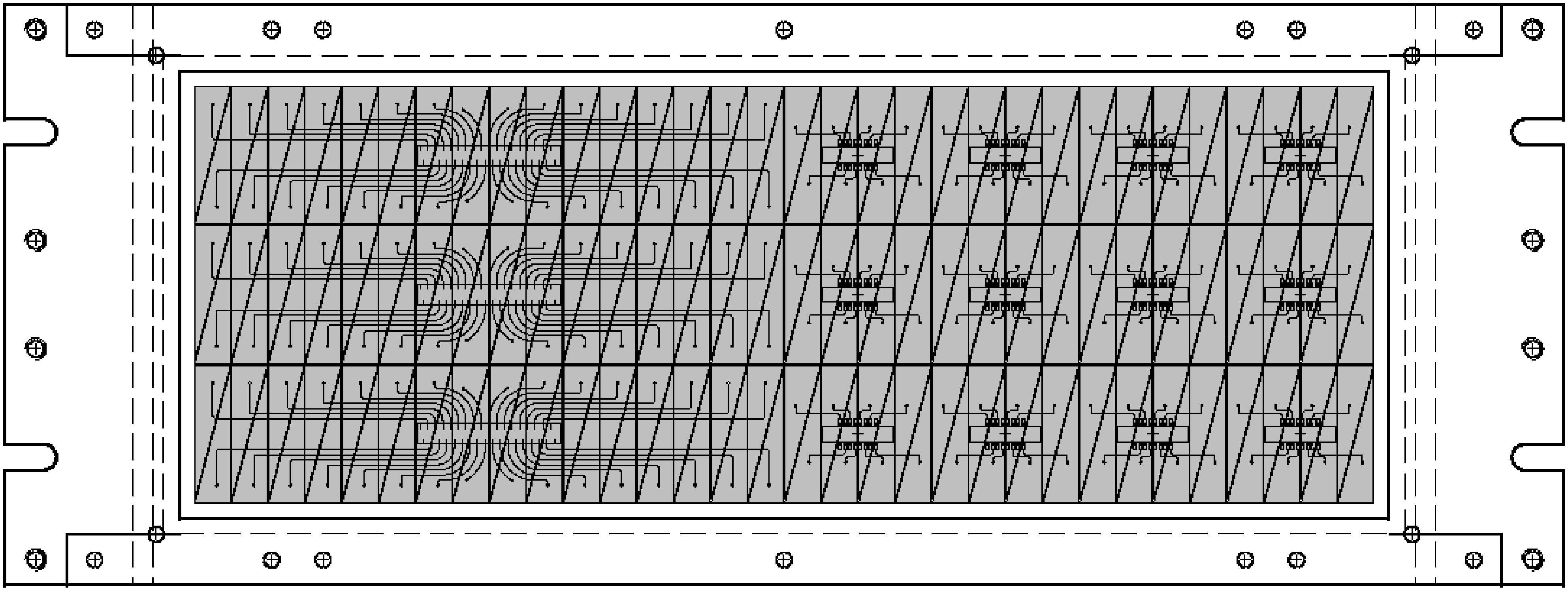






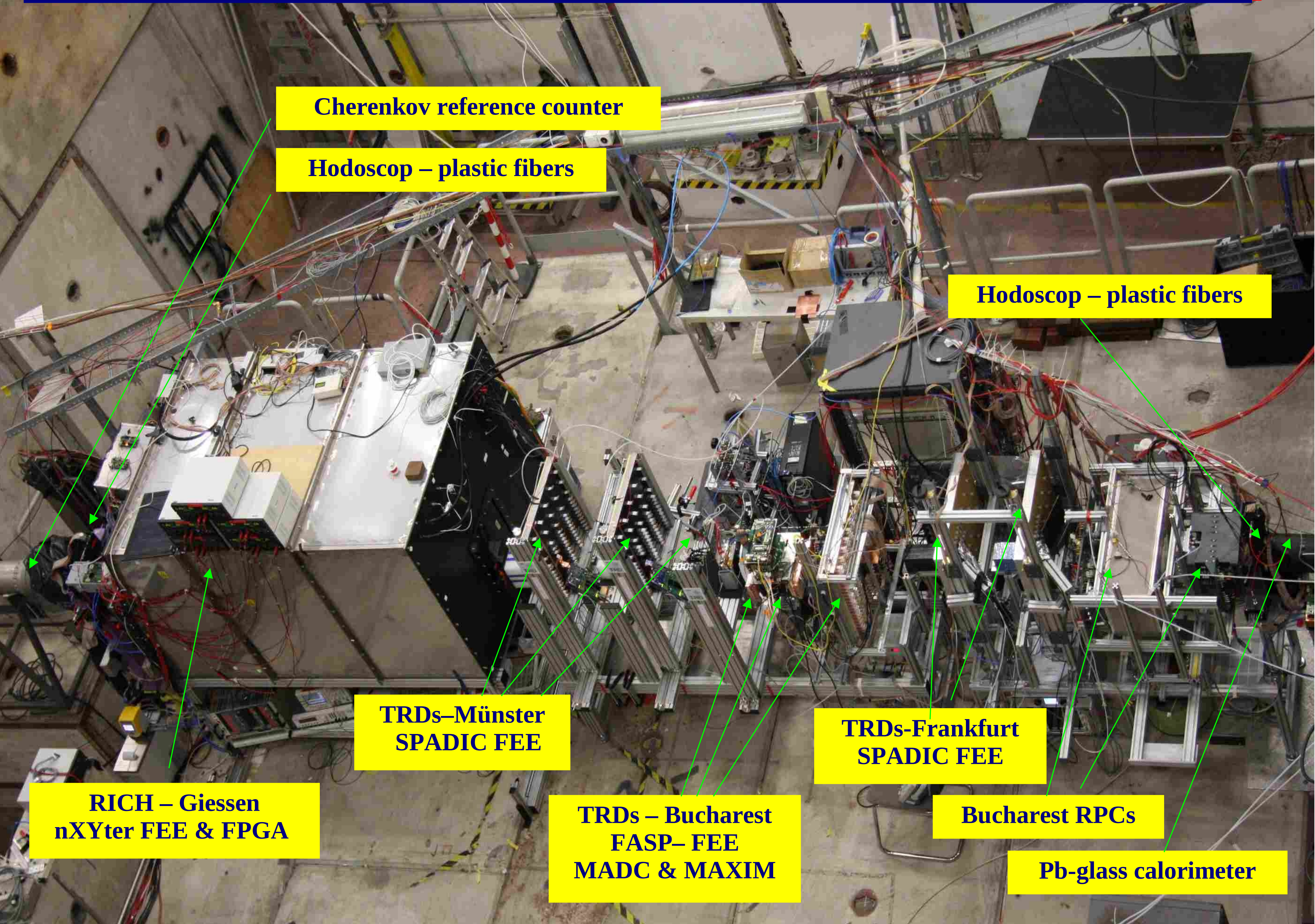
- 3 mm anode wire pitch (20 μm Au/W wires)
- 1.5 mm cathode wire pitch (70 μm Cu-Be wires)
- drift electrode=8mm Rohacell plate + Al kapton

Read-out electrode



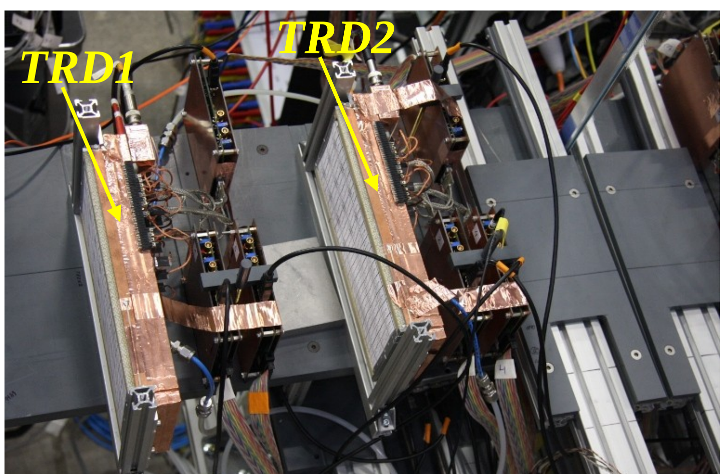
- ***readout electrode: PCB 300 µm***
- ***triangular shape of pads: position information across and along the pads***
- ***readout cell area (0.7 x 2.7)/2 ≈ 1 cm²***
- ***192 triangular pads***
- ***active area of 8.5 x 23 cm²***

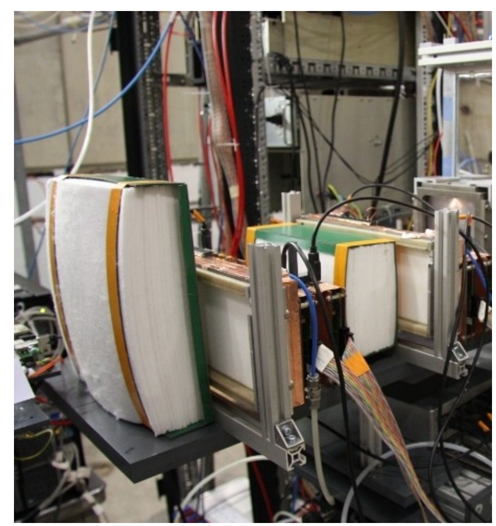
Experimental setup @ T9 beam line of CERN PS



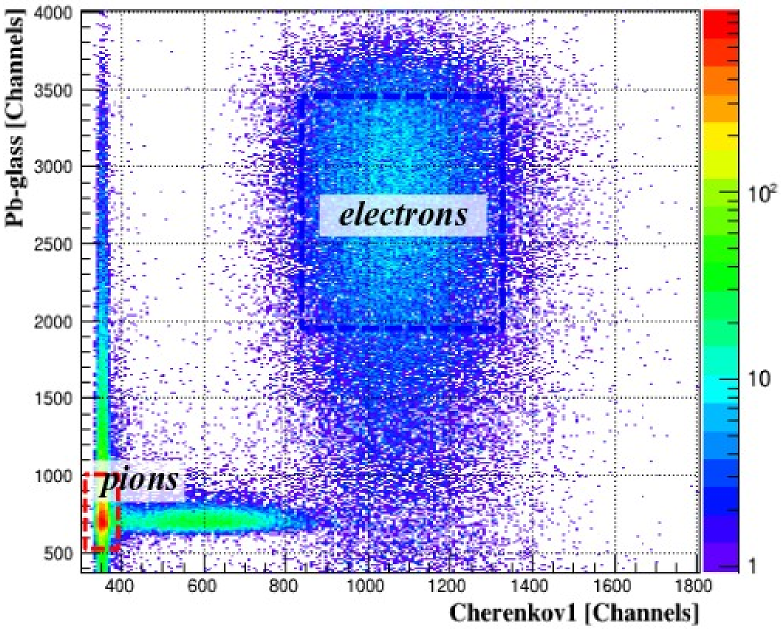
Beam conditions

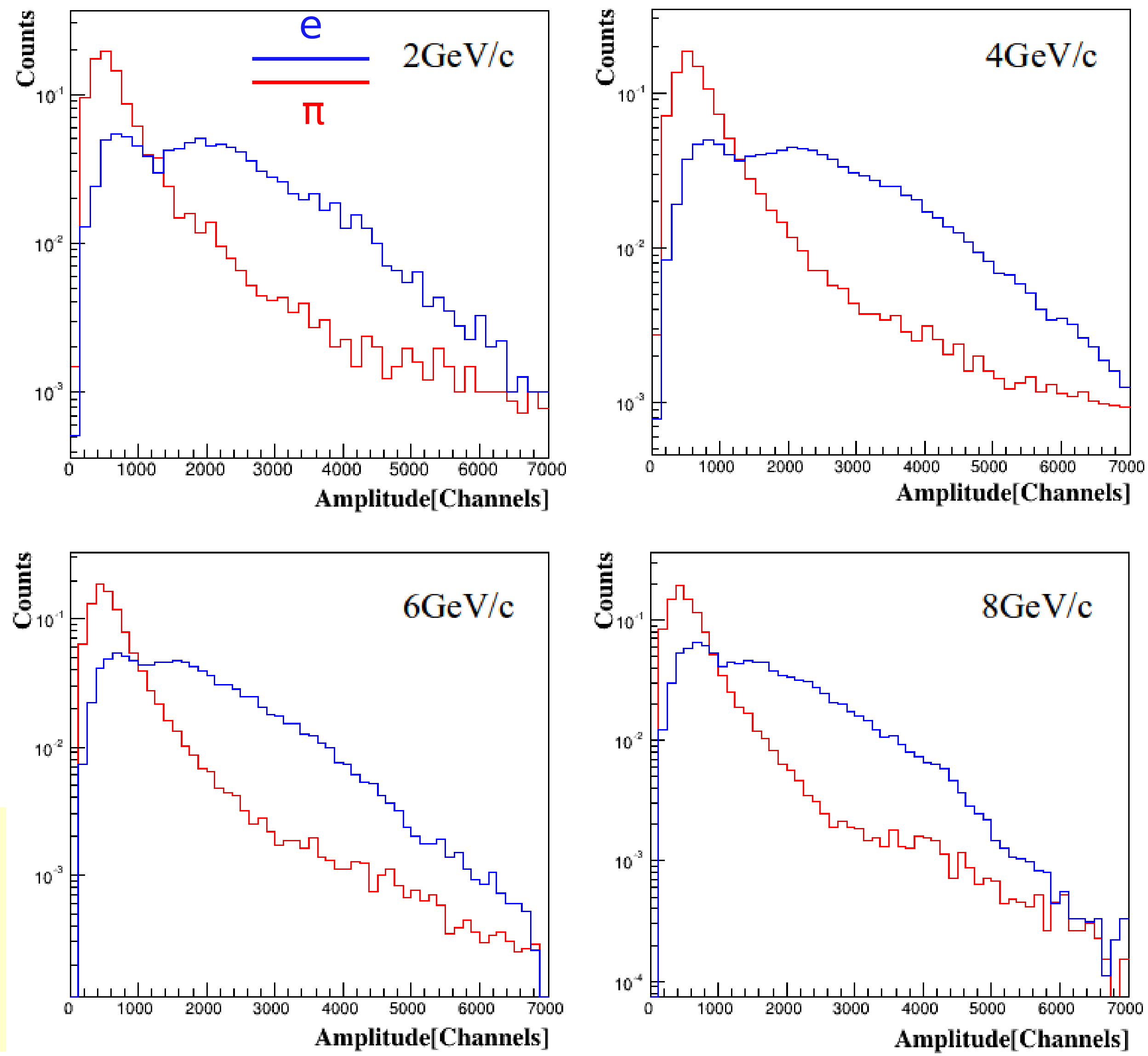
Conditii de fascicul		un fascicul mixt de electroni si pioni impulsul particulelor 2-10GeV/c	impulsul particulelor 2-8GeV/c
Prototipuri testate		2 prototipuri TRD de dimensiuni mici	2 prototipuri TRD de dimensiuni mici si un prototip TRD de dimensiuni reale
FEE		FASP-VO.1 cu semnal de iesire de tip "flat-top" si timp de formare a semnalului de 40 ns	
Digitizarea semnalelor		ADC Mesytec cu 32 de canale	
DAQ		Multi-Branch System	
Conditii de operare	**diferite tipuri de radiatoare**	folii, fibre, spuma, bule, etc.	
	tensiune inalta	HV_a=1800V-2100V HV_d=400V-800V	HV_a=2000V-2100V HV_a=800V
	amestec de gaz	Ar+CO_2 (80%+20%) Xe+CO_2 (80%+20%)	Xe+CO_2 (80%+20%)
Semnale preluate de la		pad-uri triunghiulare individuale paduri rectangulare = pad-uri triunghiulare grupare cu ajutorul unui conector special	





Pulse Height distributions for electrons and pions



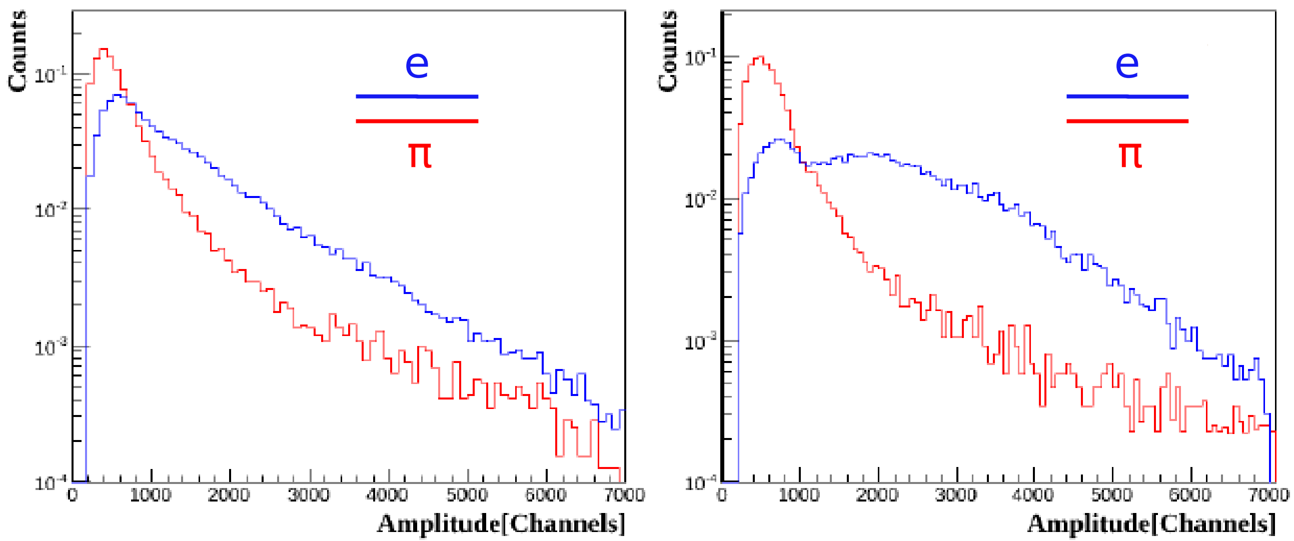


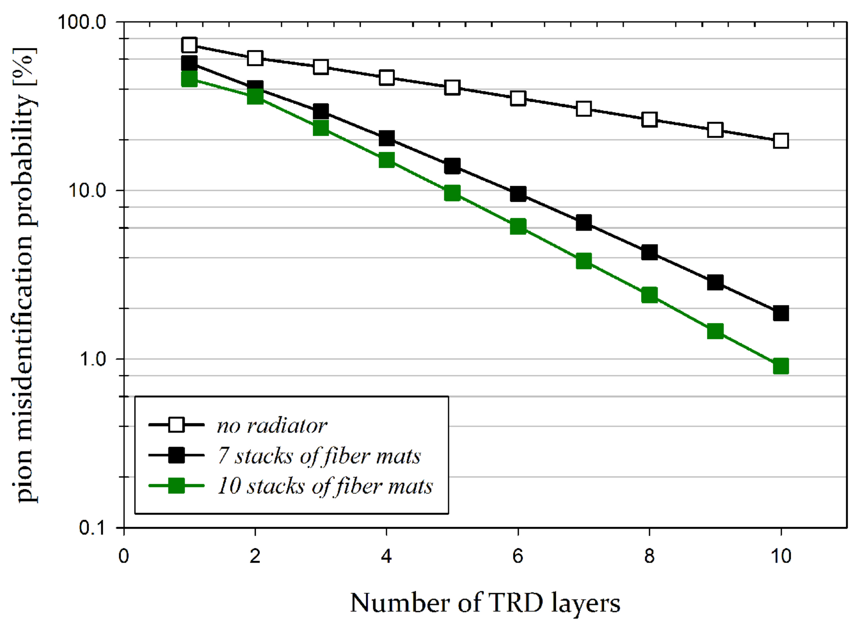
TRD operation

- **regular foil radiator Reg2**
(220 foils 20 µm thick, consecutive foils are separated by a 250 µm gap)
- **HVa = 2000 V; HVd = 800 V**

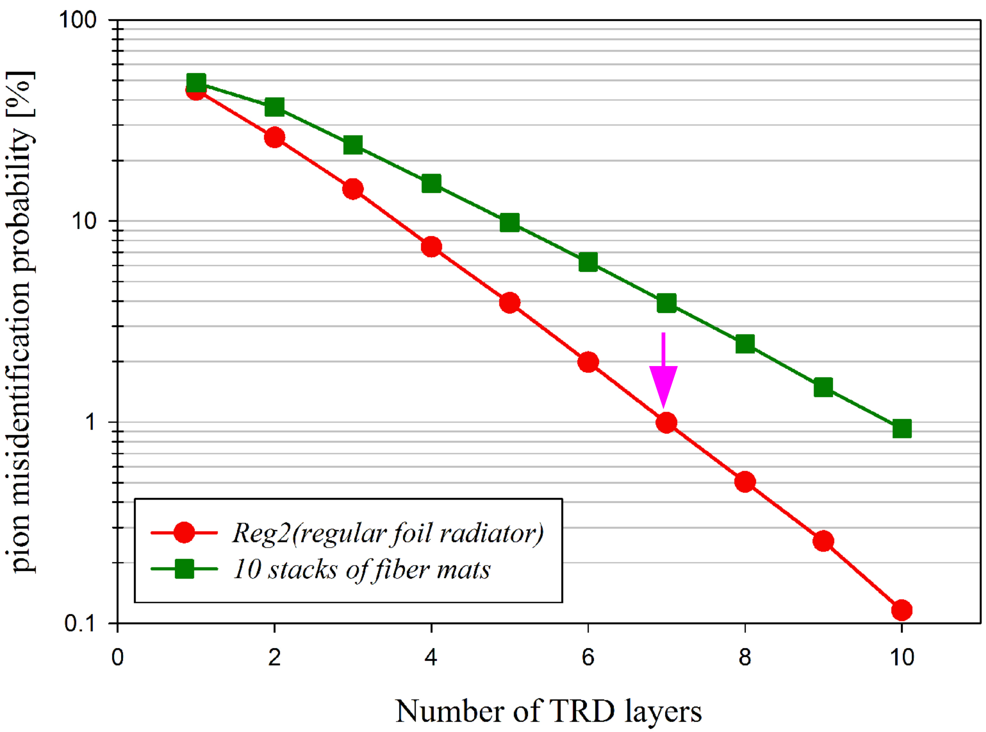
Pion misidentification probability

Without radiator **With radiator**



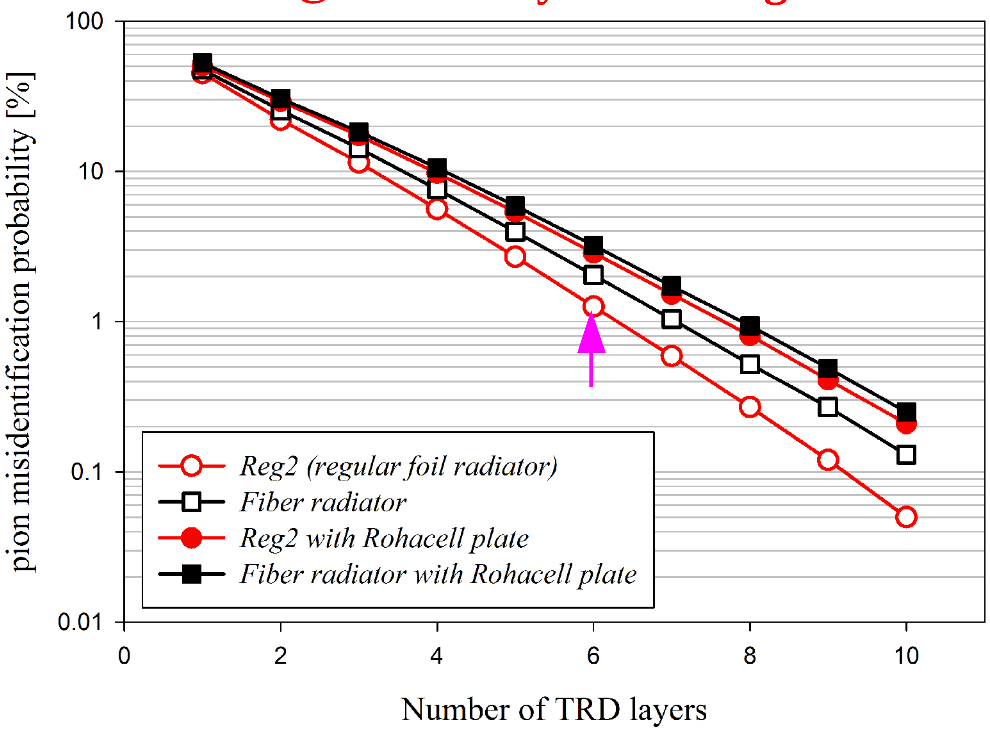


Pion misidentification probability



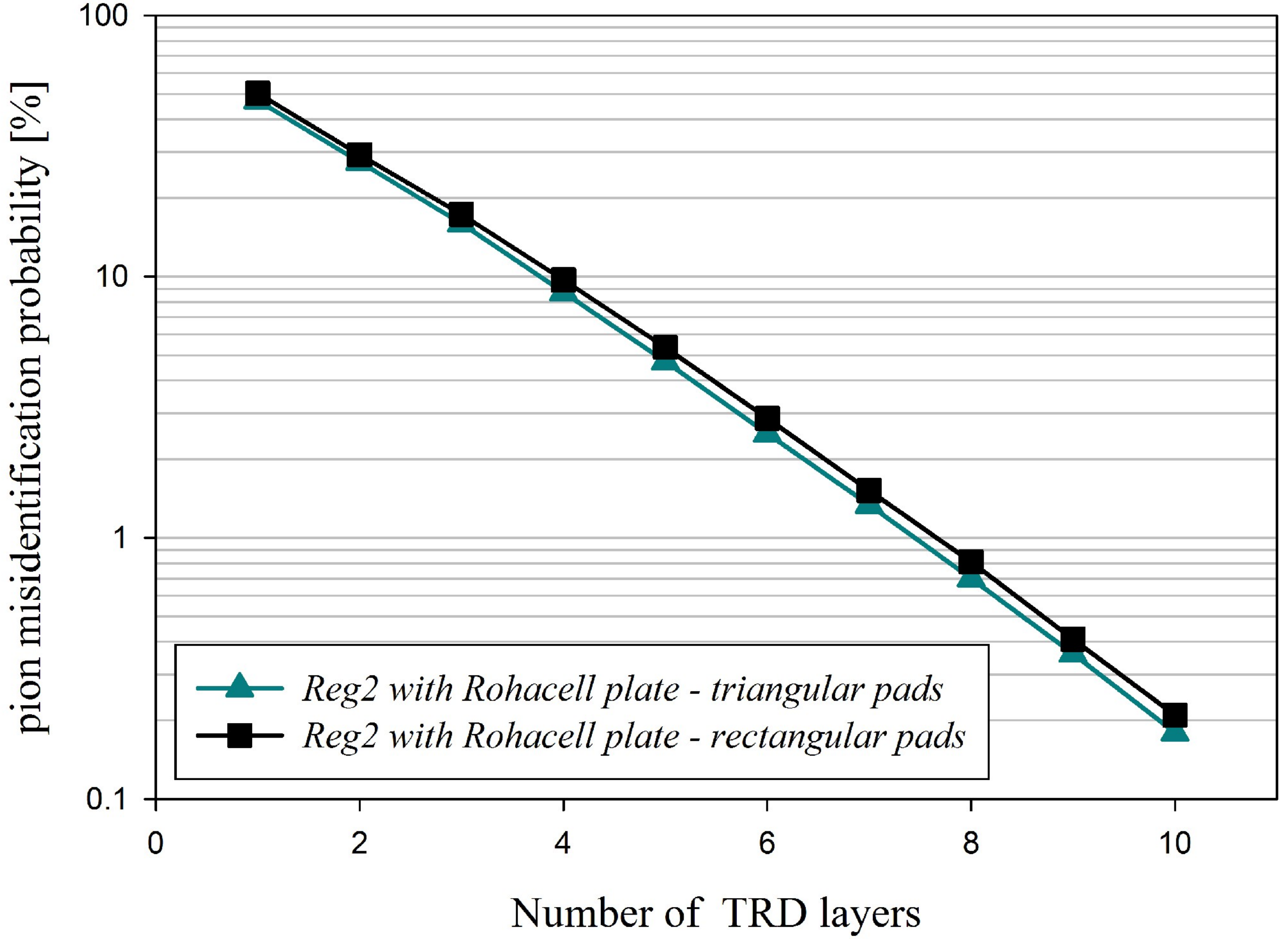
Comparison between pion efficiency obtained with a fibre Radiator (10 fibre mats) and a regular foil radiator (araldite included as absorber)

1.25% @ 6 TRD layers for Reg2

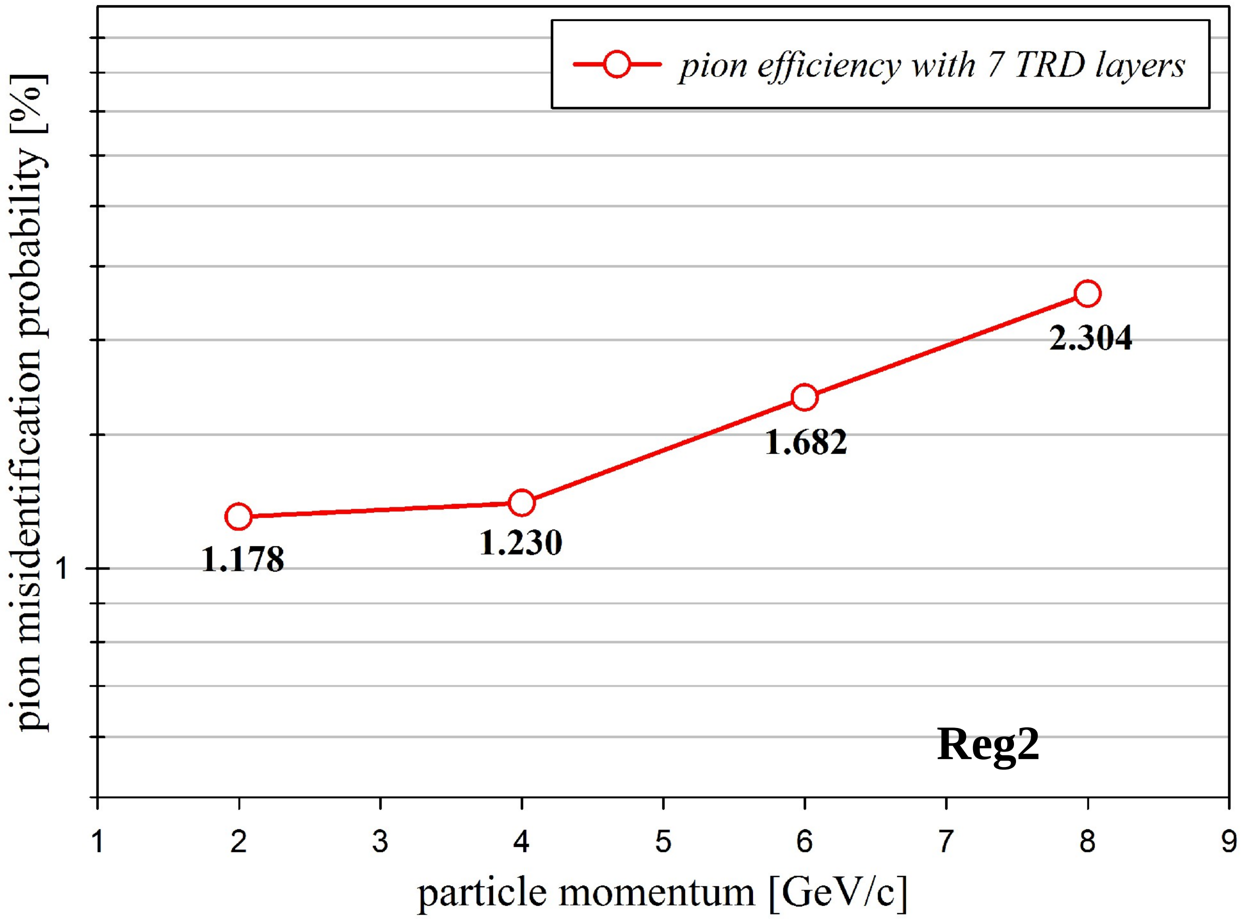


Comparison between pion efficiency obtained with a fibre radiator (16 fibre mats) and a regular foil radiator with/without a 8 mm Rohacell plate as absorber

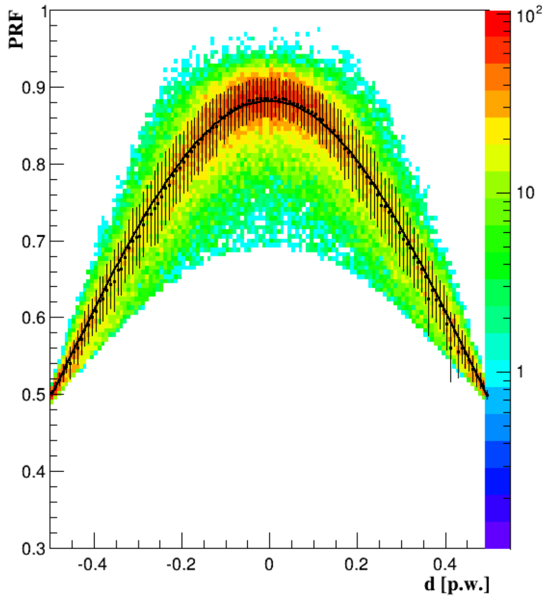
Comparison between the read-out methods



Pion misidentification probability as a function of momentum



Position Reconstruction



Pad response function for rectangular pads

Track position relative to the center of the pad with maximum charge (Q_i)

$$d=\frac{1}{Q_{i-1}^2+Q_{i+1}^2}\times\left(W_1+W_2\right)$$

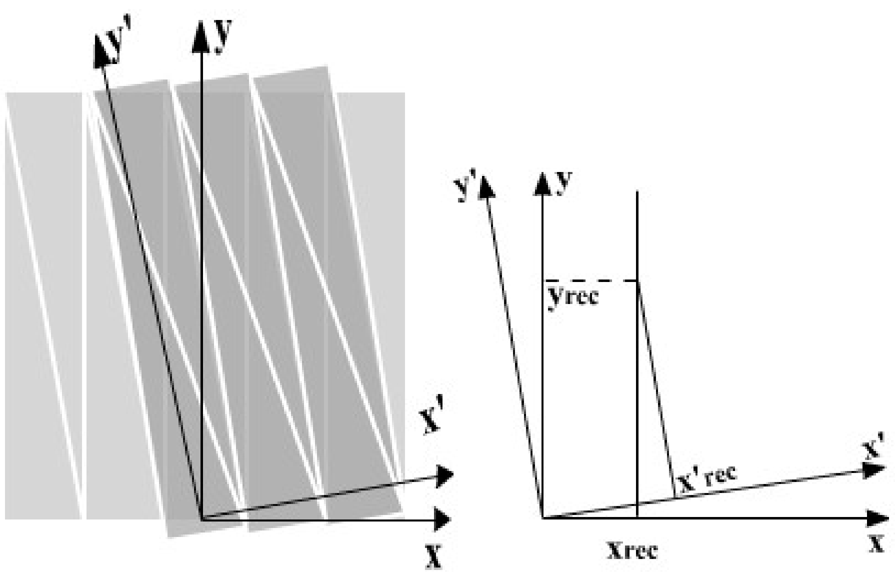
$$W_1=Q_{i-1}^2\left(\frac{\sigma^2}{w}\ln\left(\frac{Q_i}{Q_{i-1}}-\frac{w}{2}\right)\right)$$

$$W_2=Q_{i+1}^2\left(\frac{\sigma^2}{w}\ln\left(\frac{Q_{i+1}}{Q_i}+\frac{w}{2}\right)\right)$$

Reconstructed position across the pads

$$x_{rec}=d+\left(i+\frac{1}{2}\right)w$$

Reconstructed position along the pads



Pad width $w = 0.7$ cm

Algorithm:

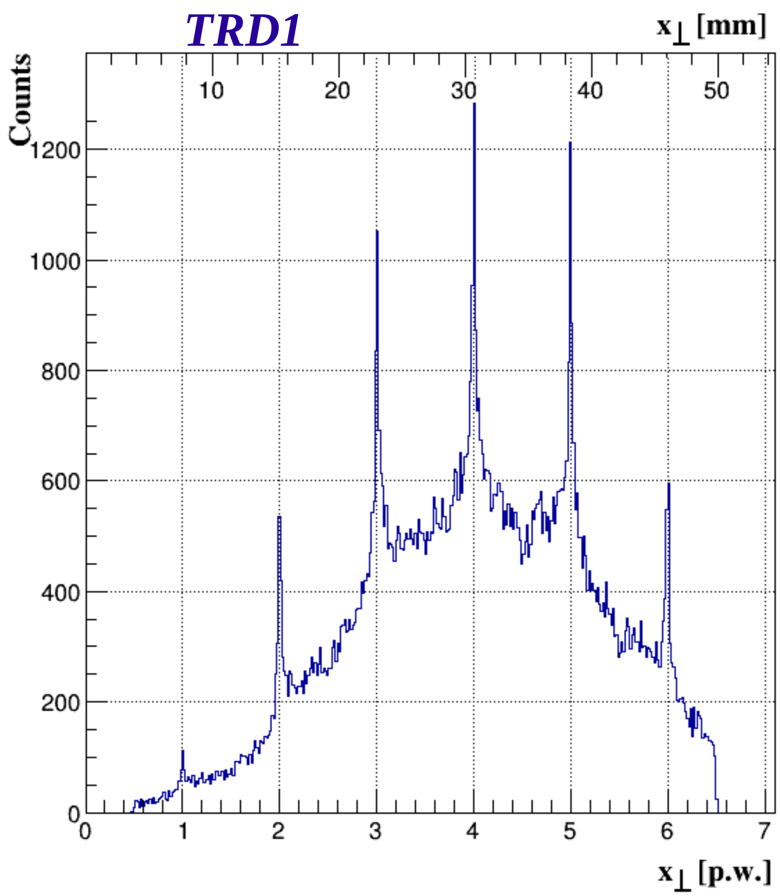
1. Pairing of triangular pads resulting:

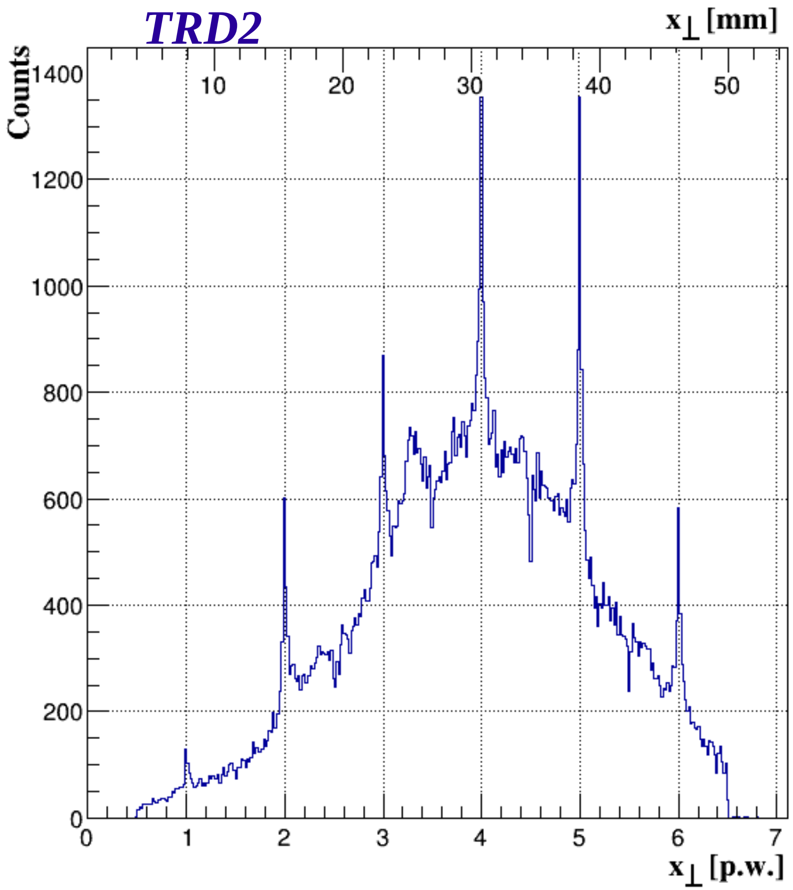
- *a rectangular pad configuration*
- *a tilted pad configuration*

2. Position across the pads is reconstructed considering clusters of 3 or 2 adjacent pads

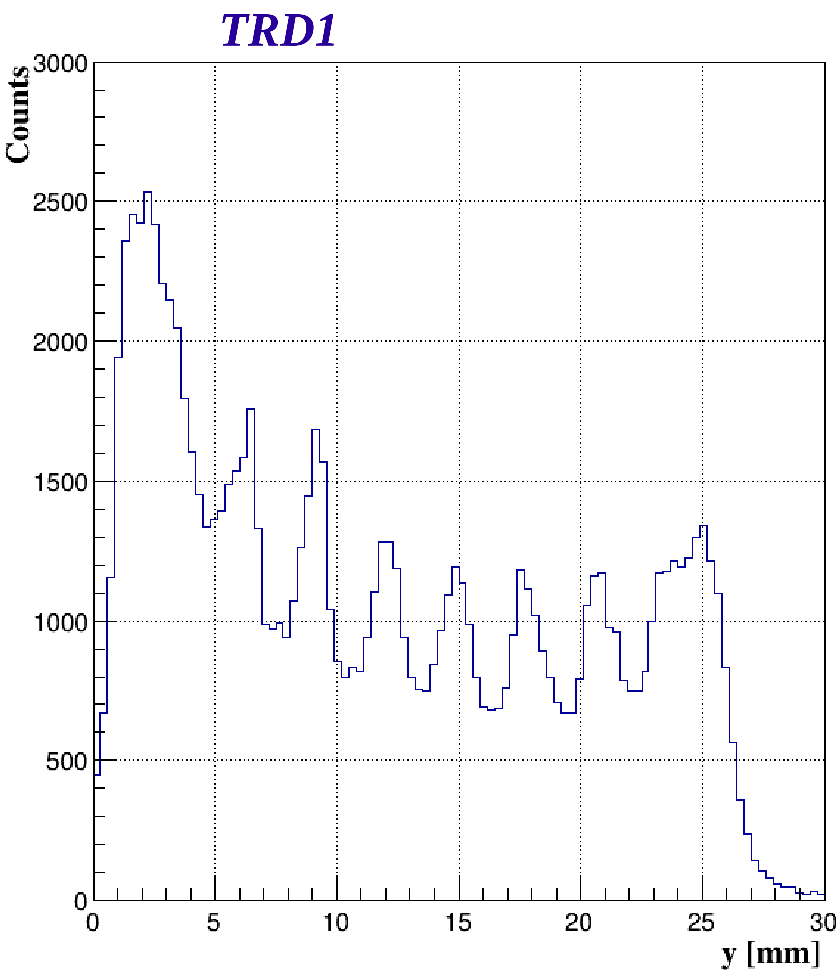
3. Position along the pads is the intersection of two lines each one parallel with the y coordinate in the systems associated with the pad configurations from above

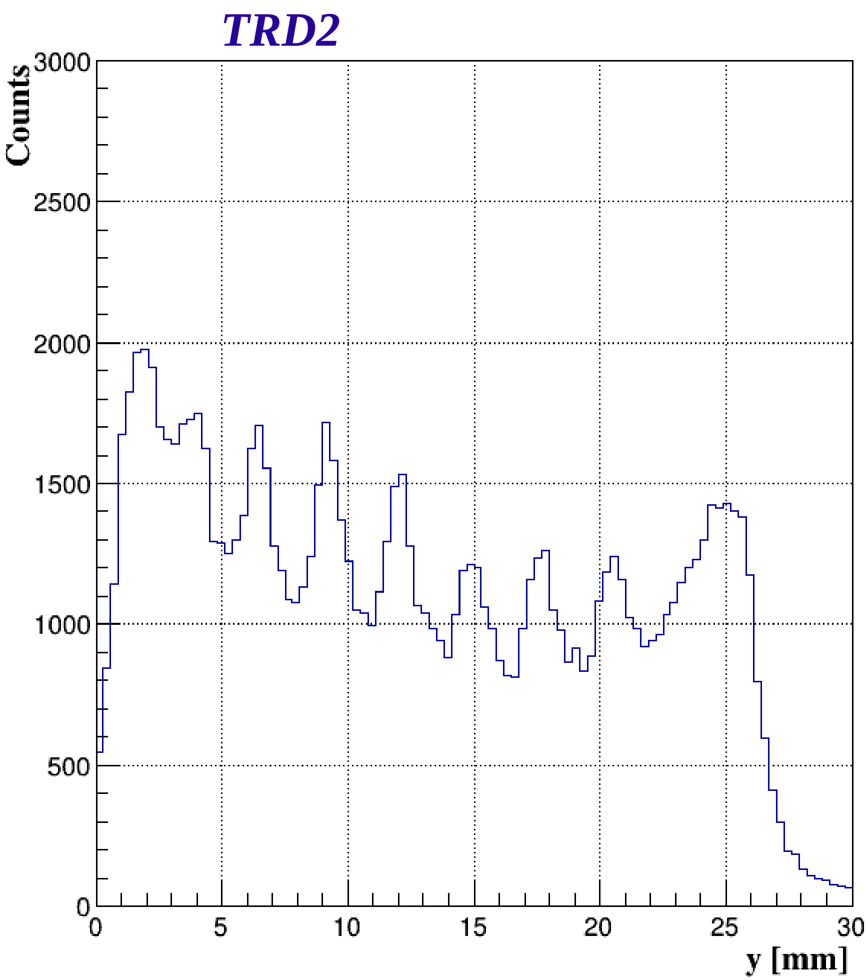
Position Reconstruction across the pads – x direction





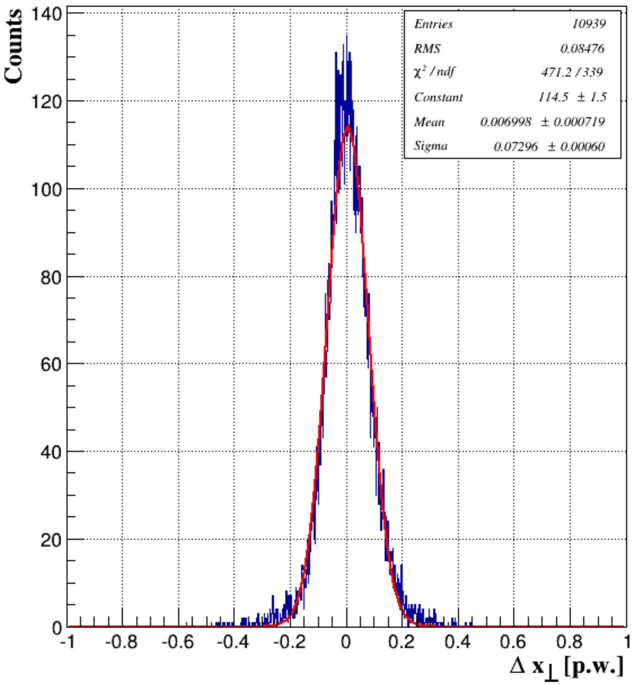
Position Reconstruction along the pads – y direction





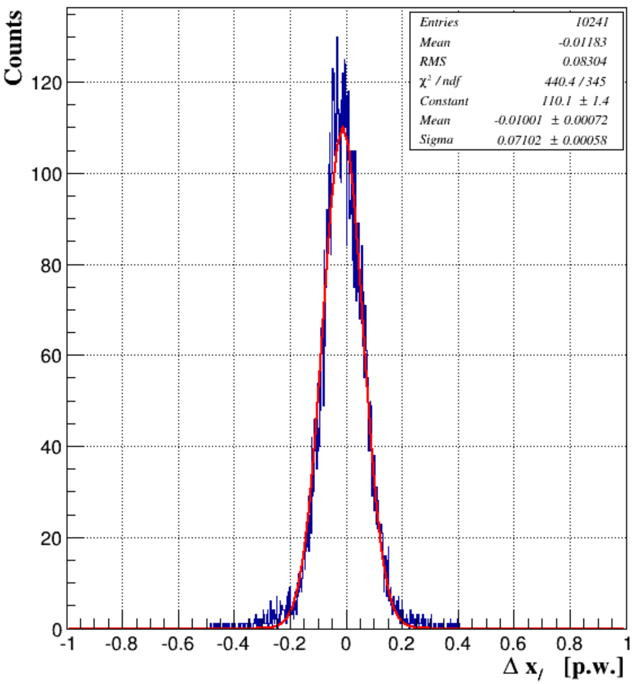
Position Resolution

position resolution across the pads rectangular pads



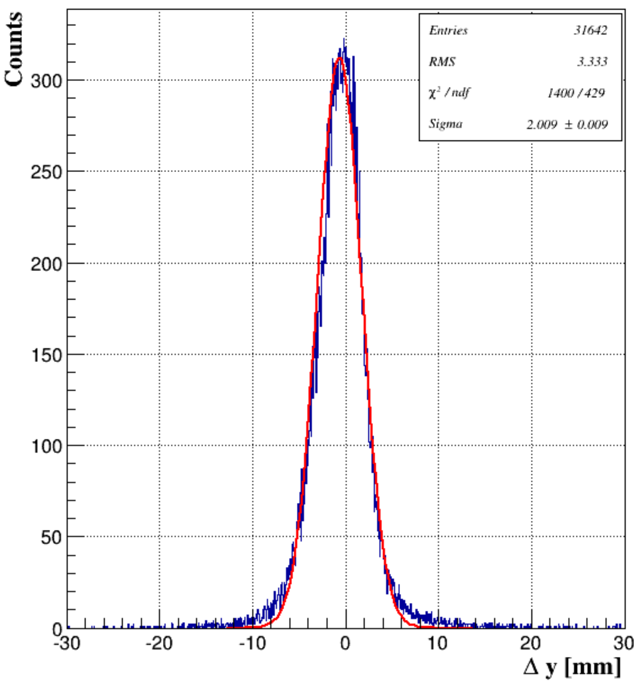
σ_x = 360 μm

position resolution across the pads tilted pads



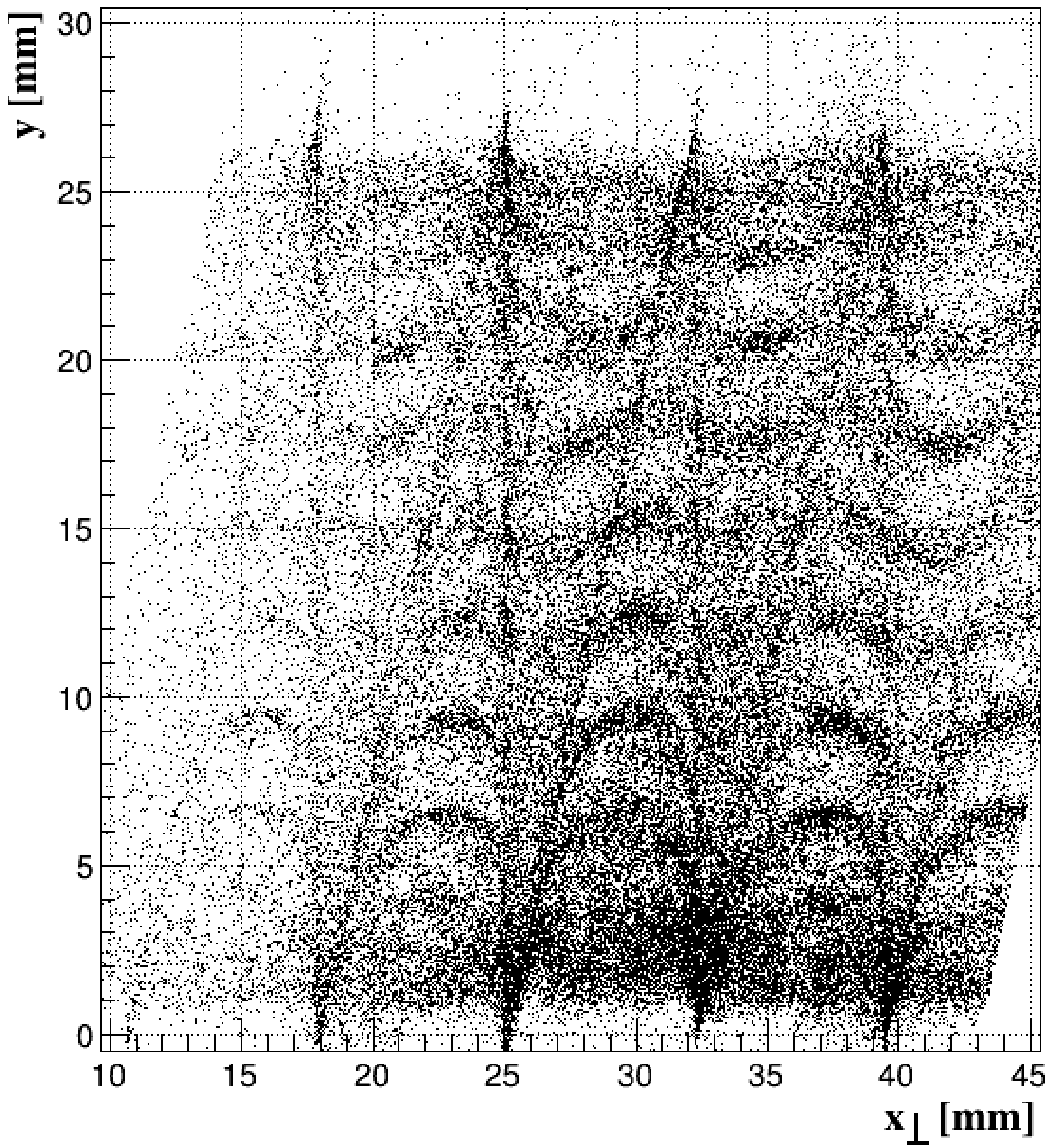
σ_x = 351 μm

position resolution along the pads

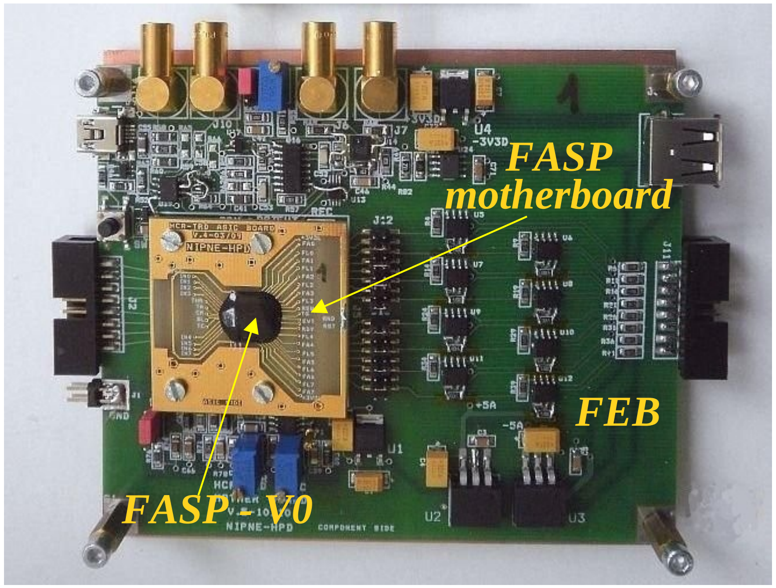


σ_y = 1.42 mm

Hit position reconstructed in two coordinates



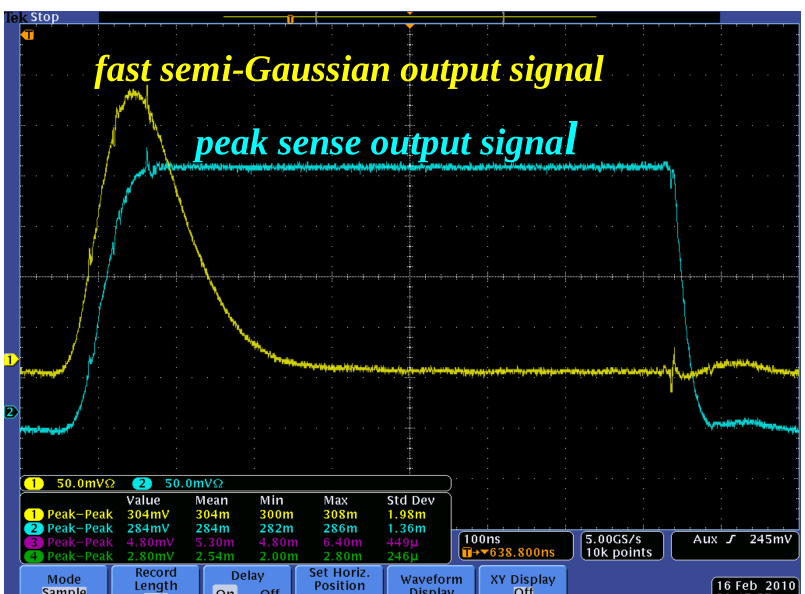
Fast Analog Signal Processor – FASP used as FEE

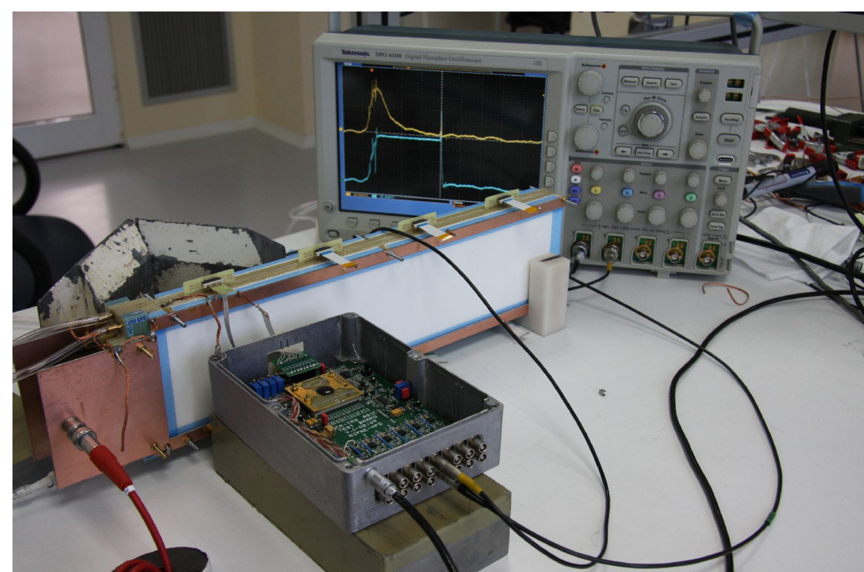


First version – FASP-VO

- *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*

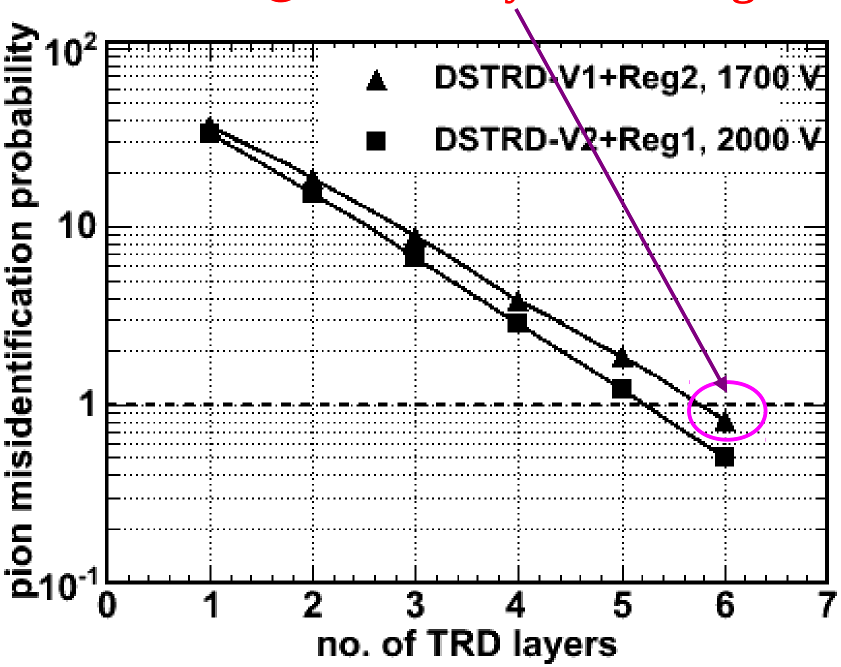
Analog channel outputs



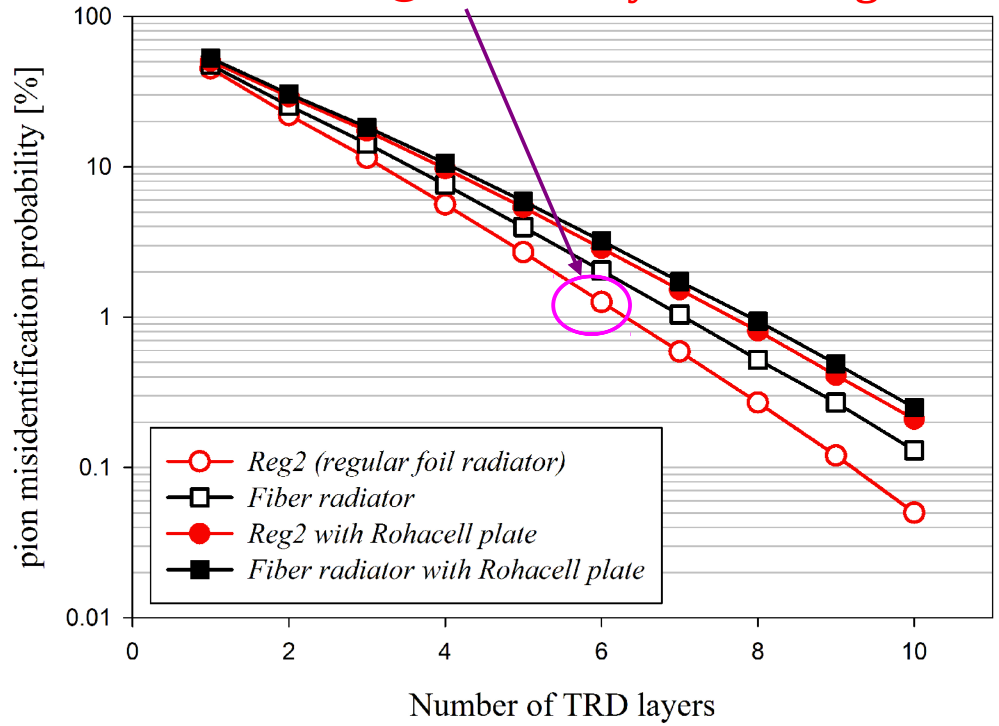


DSTRD/TRD2011 e/π discrimination comparison

0.8% @ 6 TRD layers for Reg2



1.25% @ 6 TRD layers for Reg2

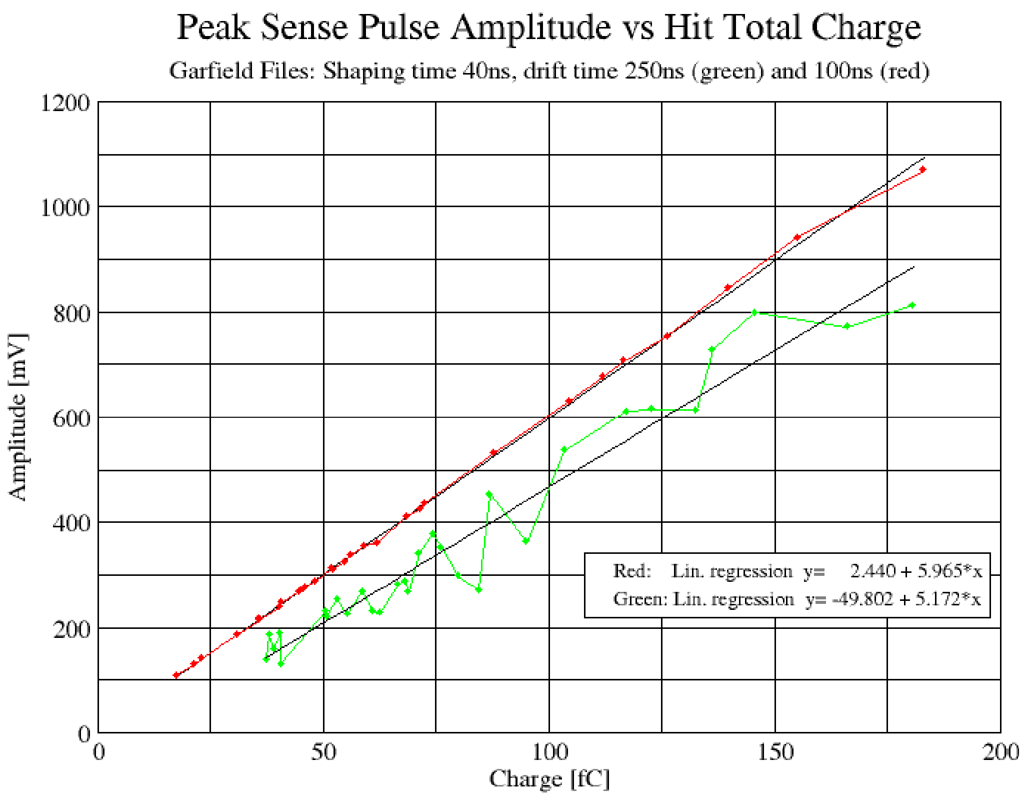


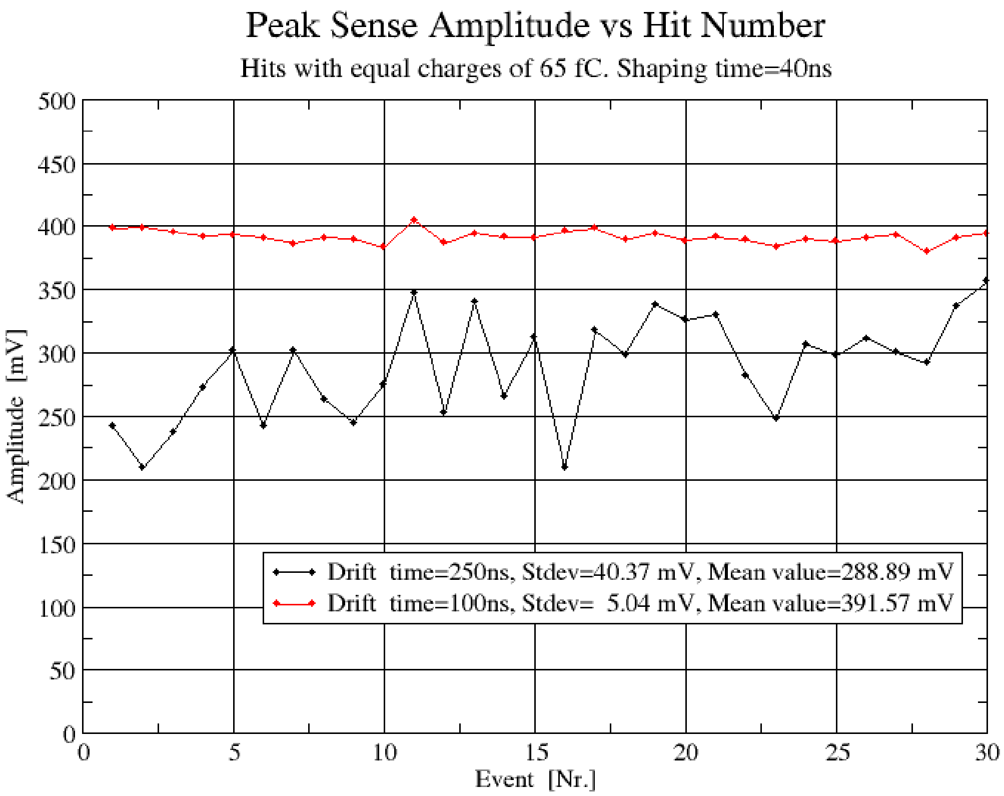
DSTRD-V1 2010 prototype:
gas thickness = 12 mm

MWPC+DZ prototype:
gas thickness = 12 mm

CADENCE simulation

- use as input detector signal simulated with Garfield
- 40 ns FASP shaping time

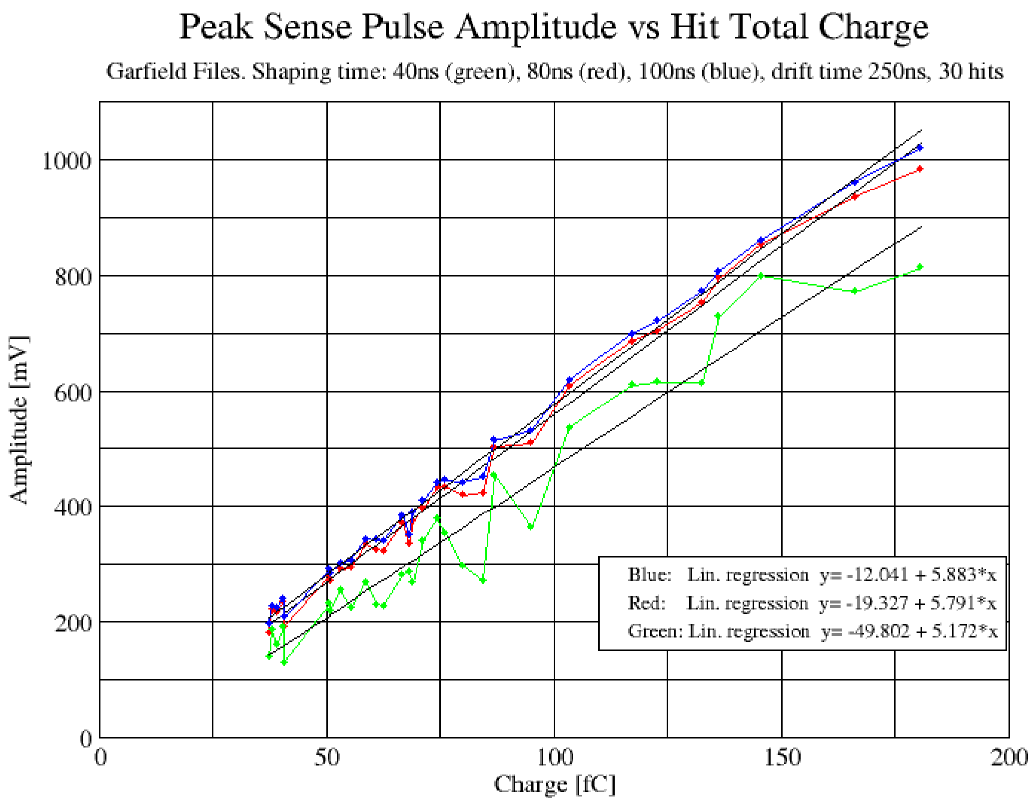


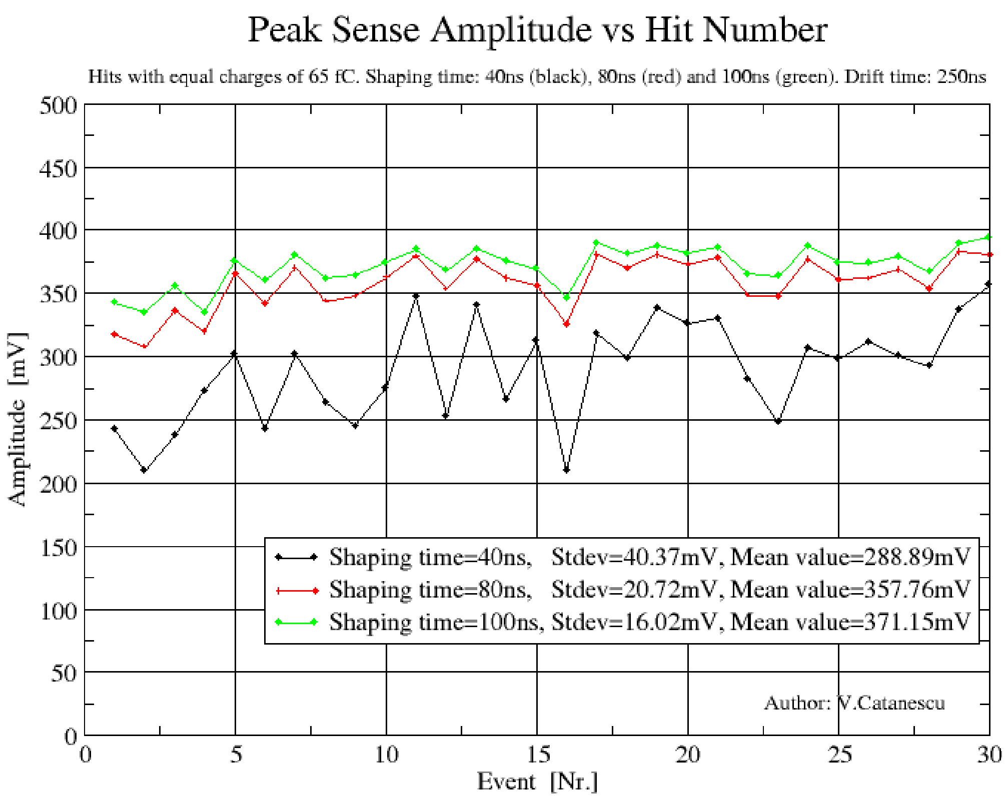


- linearity of the FASP response for hits with an input charge in the range 15 fC-170 fC having the ionization clusters randomly distributed in a time window of 100 ns for DSTRD and of 250 ns for MWPC+DZ

- uniformity of the FASP response for hits with the same input charge of 65 fC and having the ionization clusters randomly distributed in a time window of 100 ns for DSTRD and of 250 ns for MWPC+DZ

Optimization of FASP characteristics for better performance with MWPC+DZ architecture





- linearity of the FASP response for hits with an input charge in the range 15 fC-170 fC having the ionization clusters randomly distributed in a time window of 250 ns for 40 ns, 80 ns and 100 ns shaping time

- uniformity of the FASP response for hits with the same input charge of 65 fC and having the ionization clusters randomly distributed in a time window of 250 ns for 40 ns, 80 ns and 100 ns shaping time

Optimization of FASP characteristics for better performance with MWPC+DZ architecture

- *increased shaping time of 100 ns*
- *pairing of the triangular pad signals inside the ASIC chip*
- *16 input/output channels*
- *input signal polarity switch*
- *chip submission in the second part of the year*

Conclusions & Outlook

- ***Single sided architecture with (2 x4 mm + 4 mm) gas thickness operated with FASP with 40 ns shaping time has still a good discrimination performance of ~1.25% pion misidentification probability for 90% electron efficiency; geometric efficiency of a large area TRD detector based on such an architecture is high for a single layer***
- ***Split pad geometry of the readout electrode gives access to two dimensional position reconstruction with good position resolution***
- ***A new FASP version with 100 ns shaping time is under development for optimum operation of two dimensional position sensitive single sided TRD architecture***

Mandatory near future detailed investigations of:

- position resolution using high position resolution reference counter

- high counting rate and multi-hit environment on the whole active area

Papers & Conferences

★ **M. Tarzila, Master Thesis, "Towards a real size Transition Radiation Detector prototype for the planned Compressed Baryonic Matter experiment", 27 June 2013, Bucharest.**

★ **M. Petris et al., "*TRD Detector Development for CBM Experiment*", 13th Vienna Conference on Instrumentation, 11 – 15 February 2013, Submitted to Proceedings (Nucl. Instr. and Meth. A) of the Vienna Conference on Instrumentation 2013**

★ **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**

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