Calibration of the TimePix chip

&

pad enlargement chips

5th RD51 collaboration meeting

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May, 25 2010

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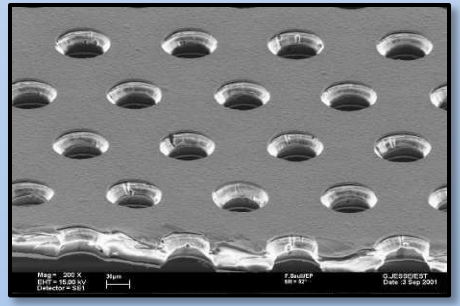
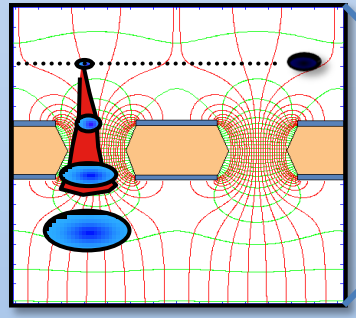
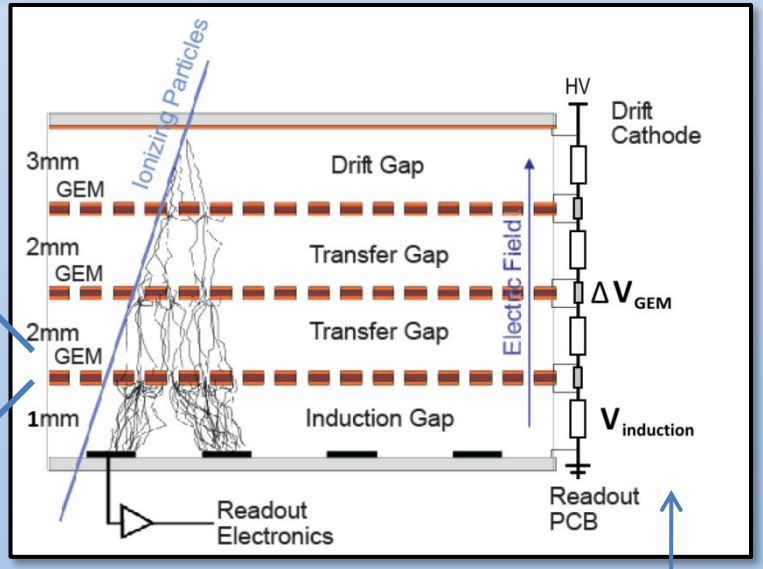
Test setup

GEM Setup



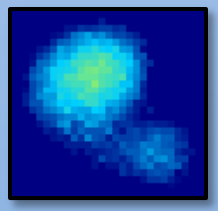




resistive voltage devider:
same potential difference (ΔV_{GEM}) per GEM

GEM+TimePix

charge is spread over *several pixels* *(>50)*



Consequences

- few e^- per channel (strong diffusion effects within the GEM-stack)

→ high gas gain necessary for detection of *minimal ionizing particles*

Pixel geometries

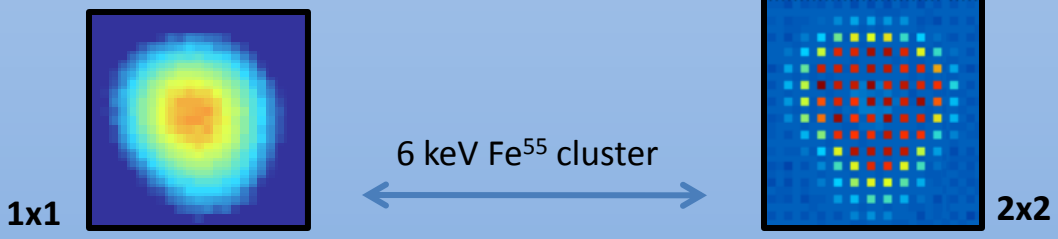
Postprocessed chips (IZM)

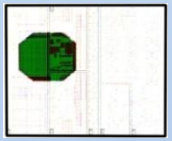
- **1x1:** metalliziation extended from ≈20x20 µm² to ≈50x50 µm²
- **2x2:** 3 of 4 pixels passivated, then metallized pixel size 105x105 µm²

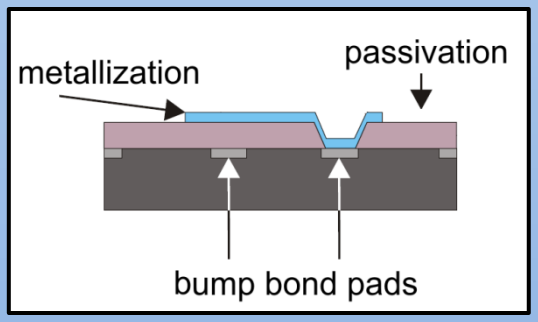
Motivation: enlarged pixels

- more charge per pixel

  → higher probability of detection
- less gas amplification needed → fewer positive Ions
- optimization of spatial resolution vs. pixel size





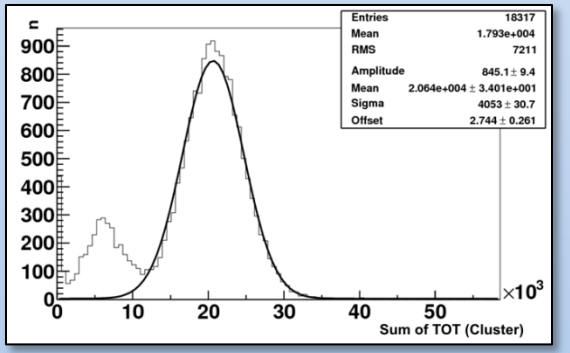


profile - postprocessed pixels

1x1 and 2x2

Setup

- gas: $HeCO_2$/ Fe55 (6 keV photons)
- 1x1 and 2x2 with similar thresholds



Example: $ArCO_2$

Procedure

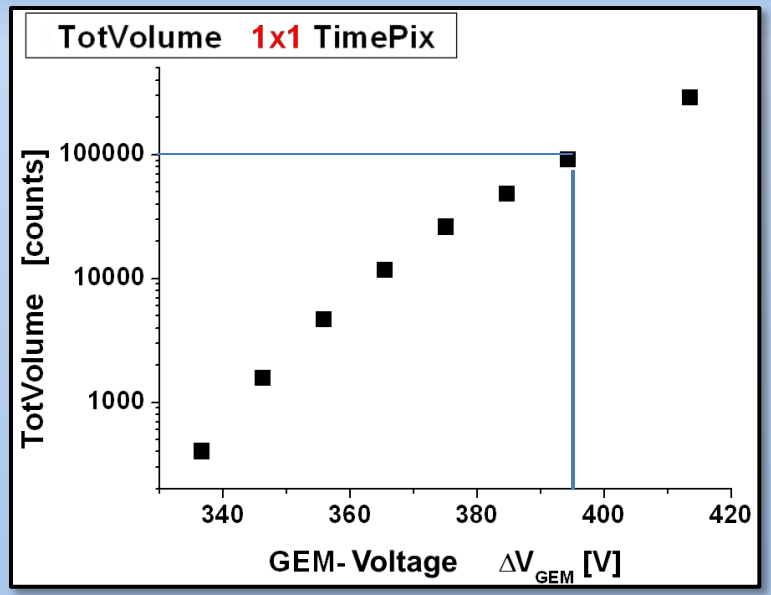
- find clusters
- sum up the *TOT* values of the pixels (TOT - counts clock cycles above a chosen threshold)
- fit gauss (peak)
- take mean = *TOTVolume*

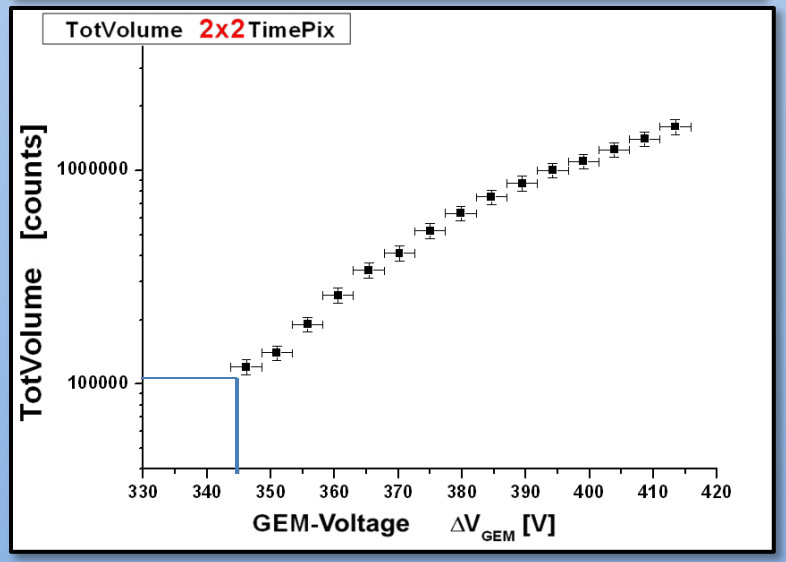
Comparison

with **pixel enlargement:**

→ **less gas gain needed**

(ΔV_{GEM}) ≈ 50 V





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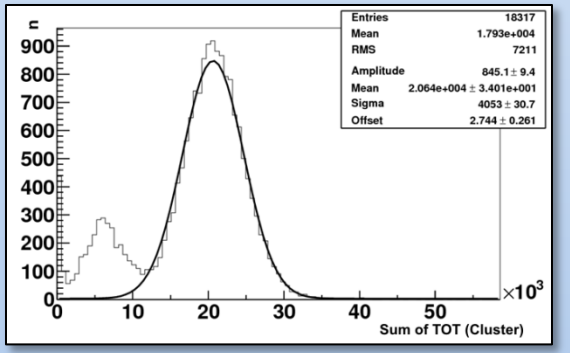

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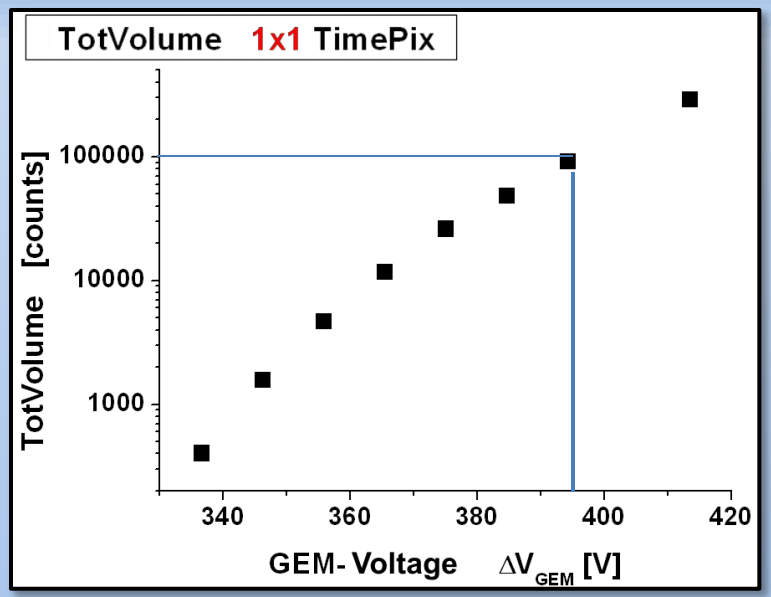
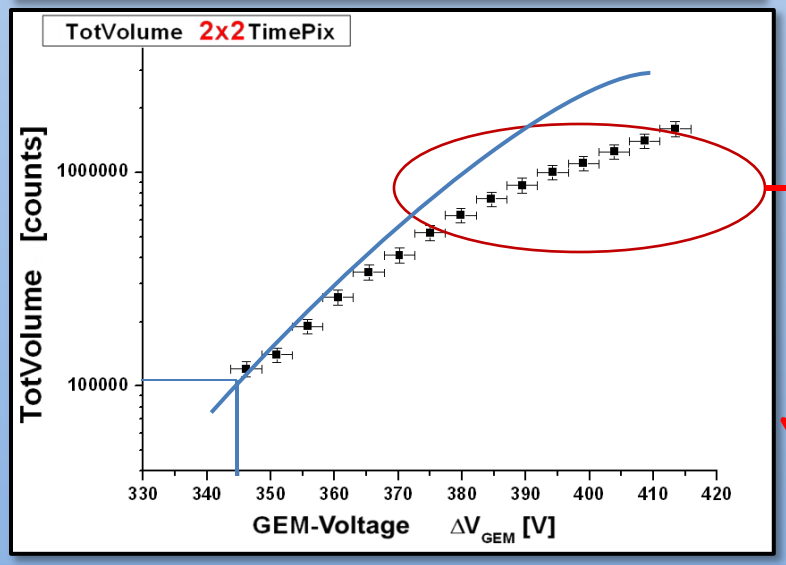


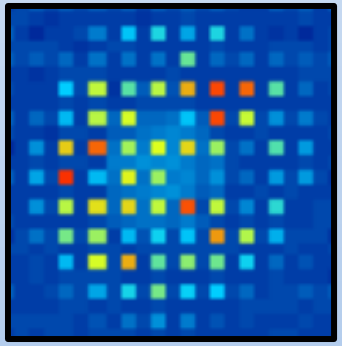


Passivated pixel cross-talk

TOT-drop

insulation of the passivation not sufficient

→ charge on masked pixels

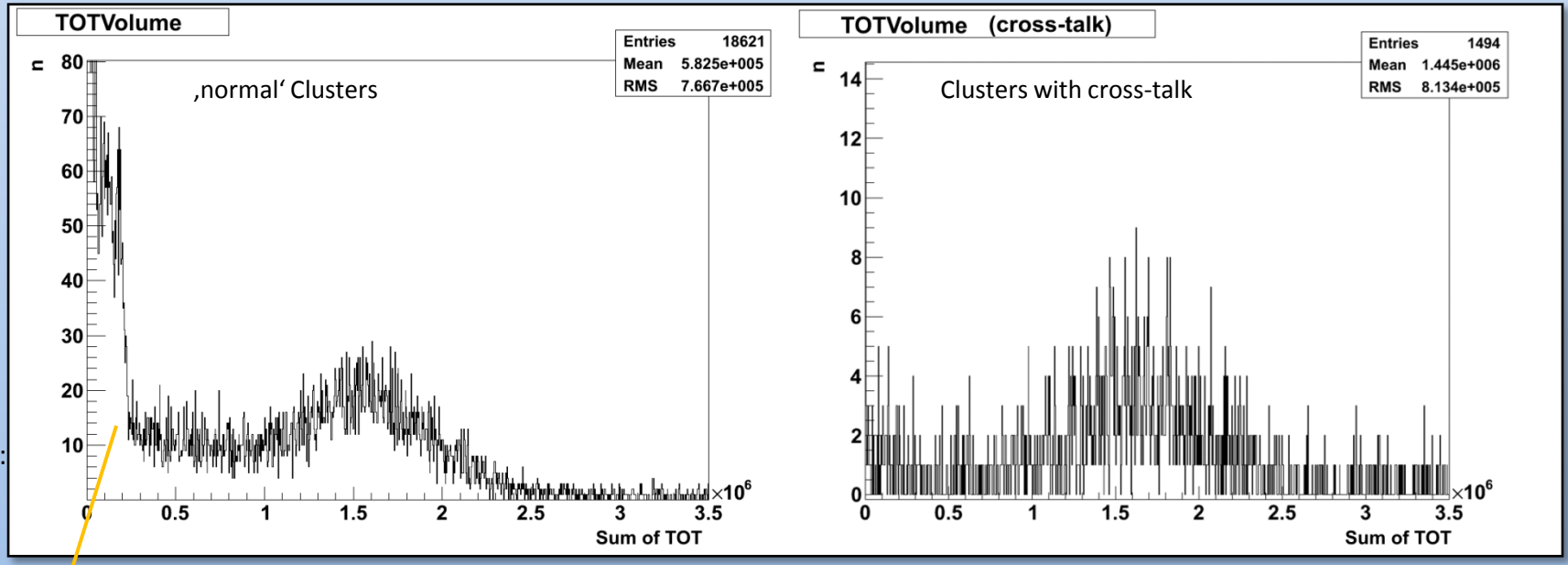


Fe55-source
Volt./GEM: 385V
2x2 all pixels

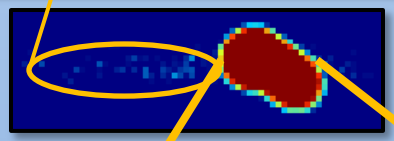
Does cross-talk depend on the **deposited charge**?

Passivated pixel cross-talk

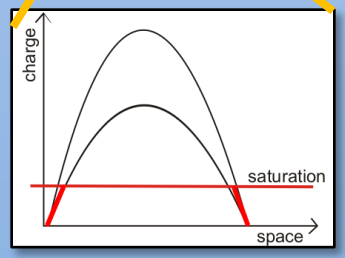
TOT-drop



2x2
Fe55 source
GEM voltage:
415 V



just
noise



profile of a
saturated cluster

Procedure
- find clusters (min size 6 pixels)
- select clusters: with and without cross-talk

← **problem**: ‚saturation' of charge at cluster center

Simulating maximum charge

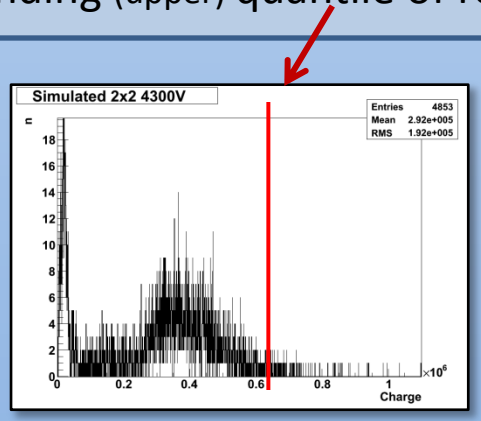
Analysis

pixels are saturated ⟶ no **real** charge information

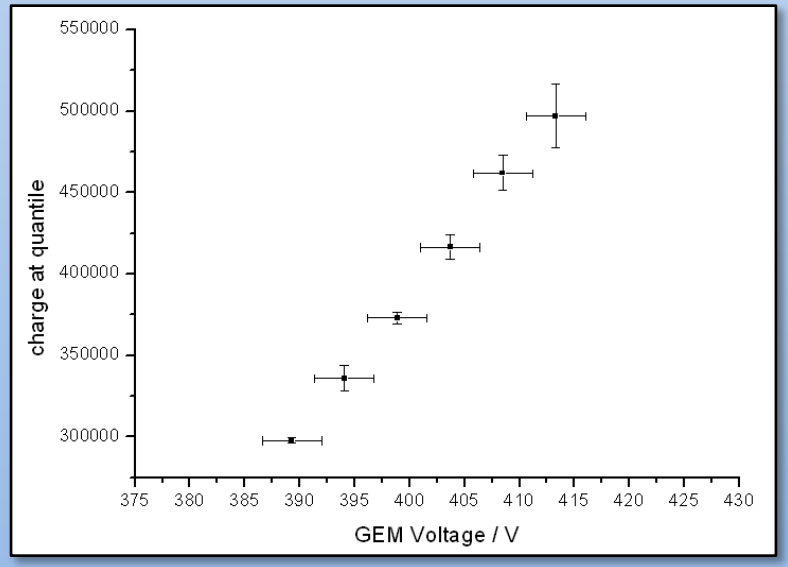
Comparison: 2x2 with a rebinned 1x1

Is there a amount of charge pixels start cross-talking?

ratio of cross-talking clusters in real data
with
corresponding (upper) quantile of rebinned 1x1



1x1 chip
rebinned to 2x2
Volt./GEM: 415V



⟶ charge at quantile should be constant

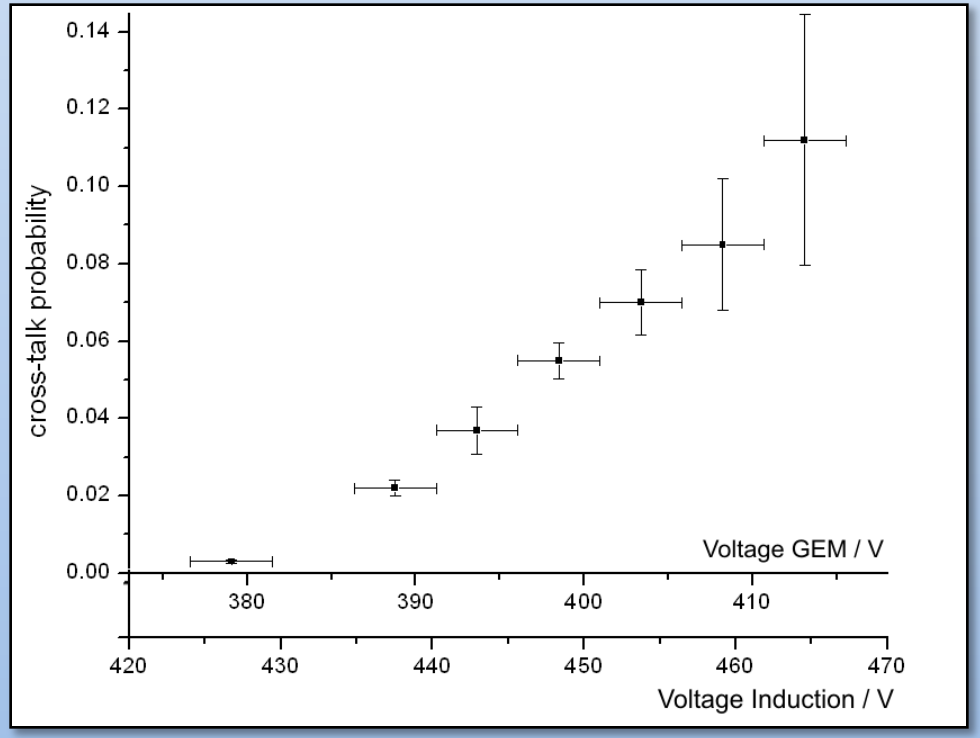
assuming a crictial charge at which passivated pixels start showing a signal

Passivated pixel cross-talk

Examine:

ratio of cross-talking clusters
vs.
applied applied voltage

Effect:
cross-talk probability depends on E-Field strenght
(not only on the amount of charge)



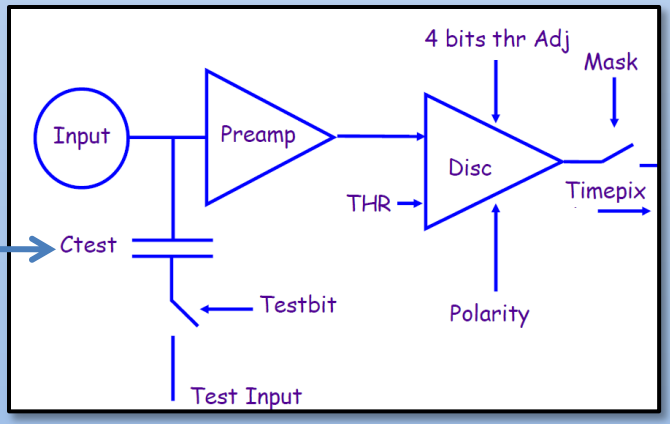
Test settings

Pixel calibration

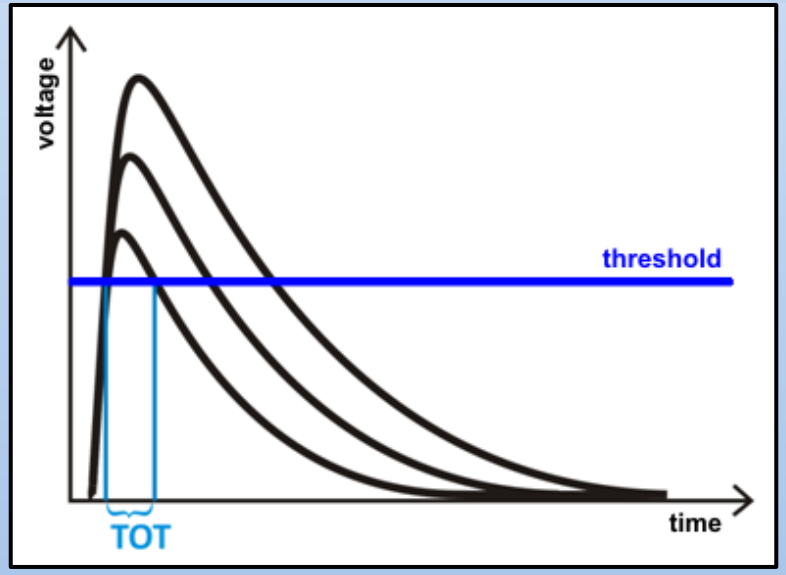
Procedure:

- test pulse at test capacity Ctest (ca. 8 fF)

→ injected charge on pixel



(TimePix manual)



scheme: charge-/ discharge curve Ctest

Interfaces

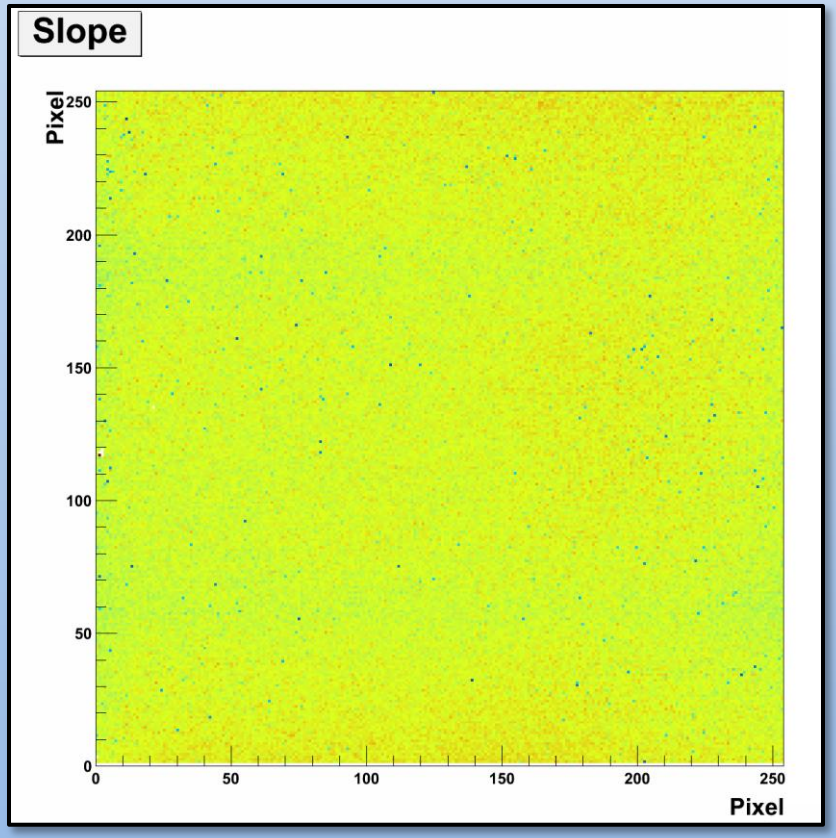
Measurements : 40 Mhz

USB

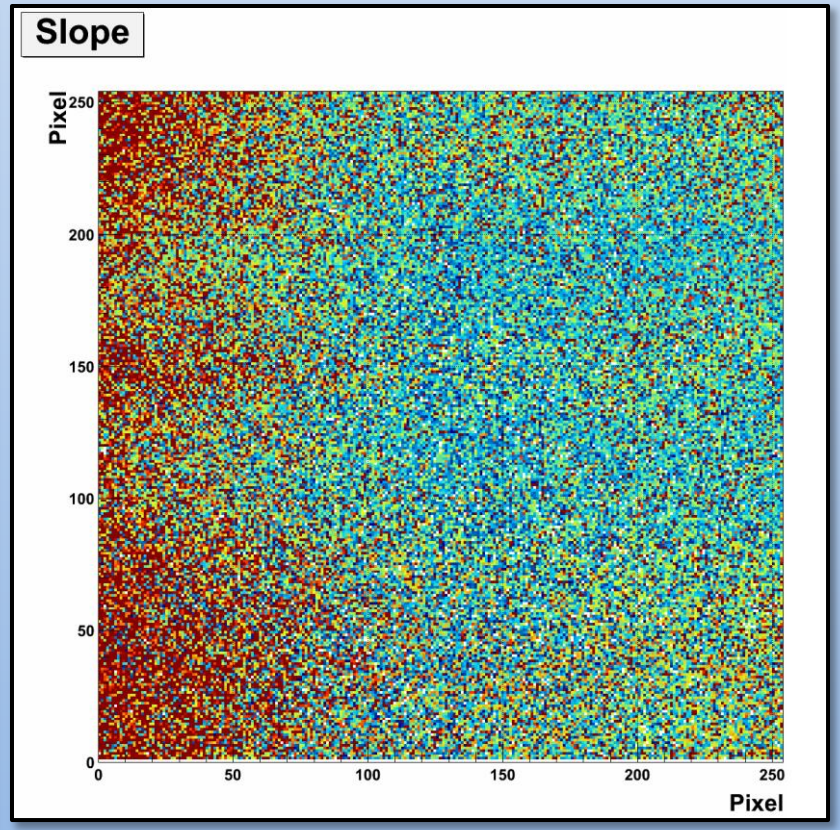
MUROS

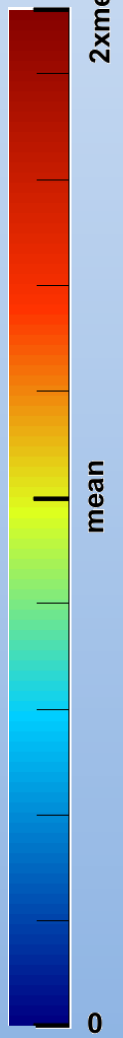
MUROS vs. USB

MUROS



USB





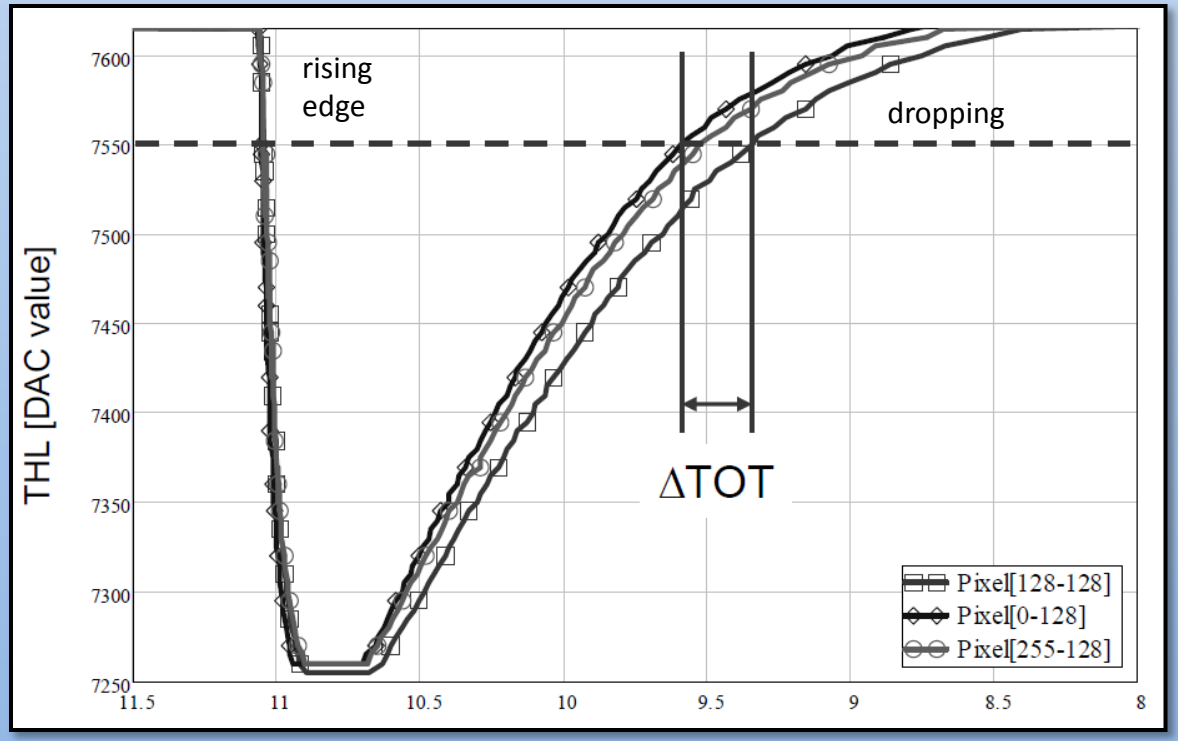
USB Interface(1.2.2): calibration with test pulses not possible

Test pulses

Problem

- current in discharging flank varies from pixel to pixel

  → variation in TOT



Design and characterization of 64K pixels chips working in single photon processing mode
Xavier Llopart Cudié 2007

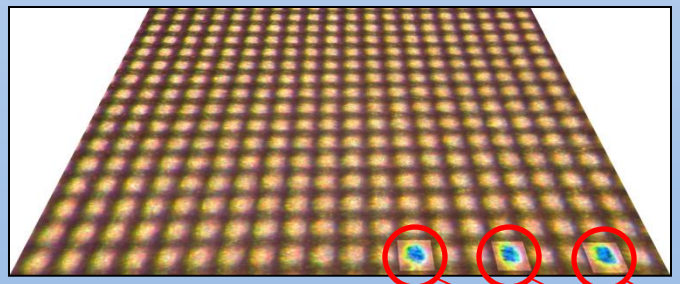
MUROS vs. USB

Until now: calibration *chipwise* (mean over all pixel)

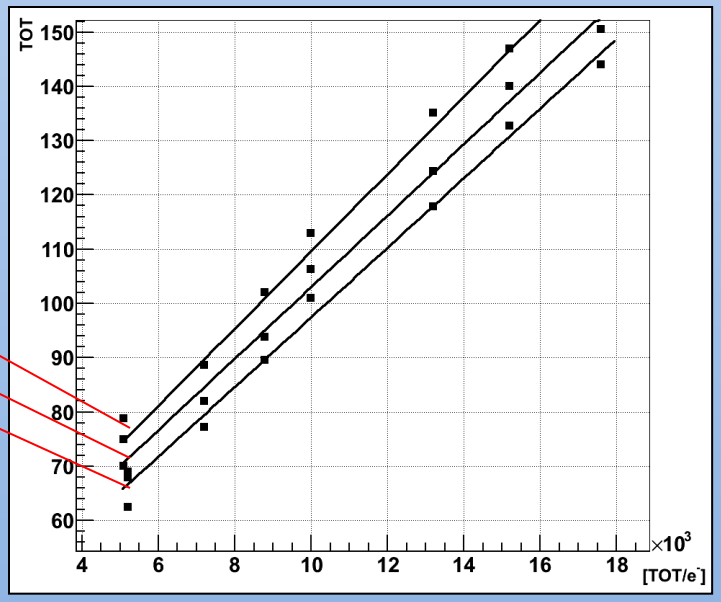
- TOT counts depend linearly on the deposited charge

$$TOT = b \cdot Q + a$$

→ every pixel has its own response function



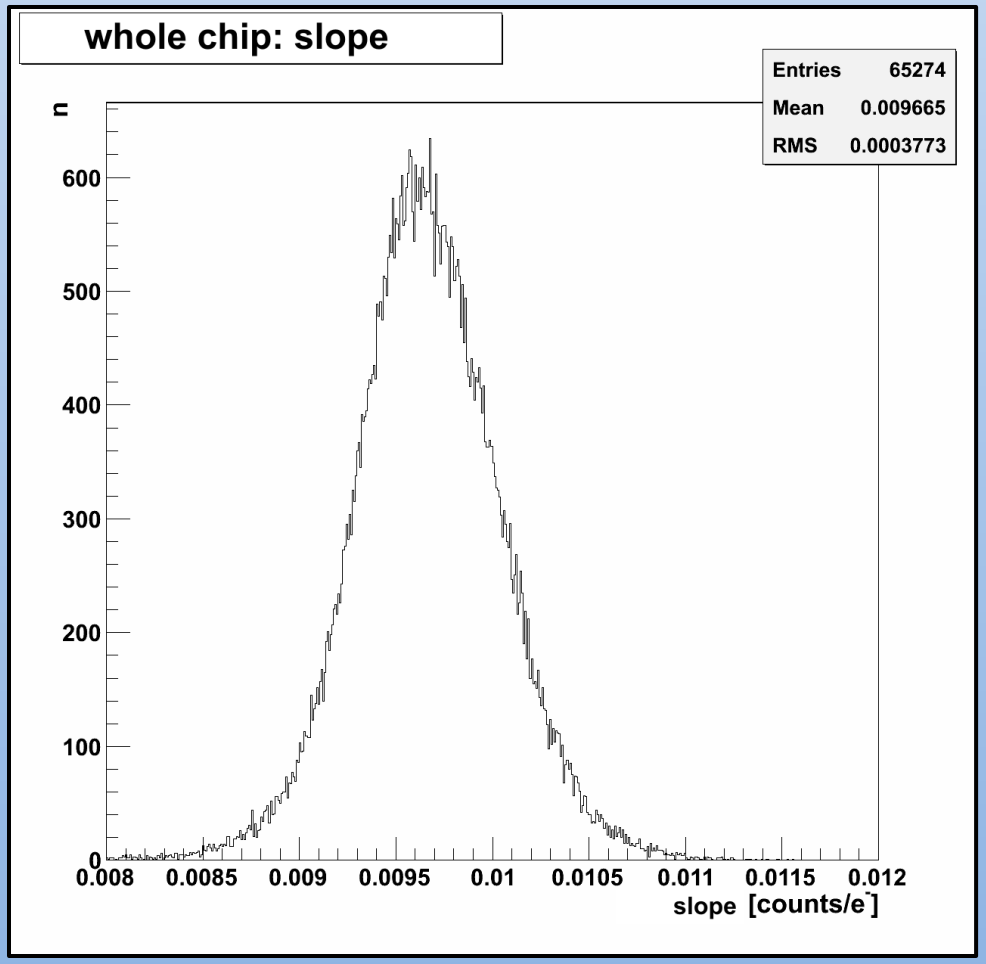
(Detail TimePix)



Will a pixelwise calibration improve the charge calibration?

Precision

Distribution of slopes (Muros)



variation of all slopes: 4%
relative error on individual pixel slope fits: 3%

Under assumption of a convolution of the given distribution of the pixels with a gauss curve (fit error):

→ variation of slopes ca. 2%

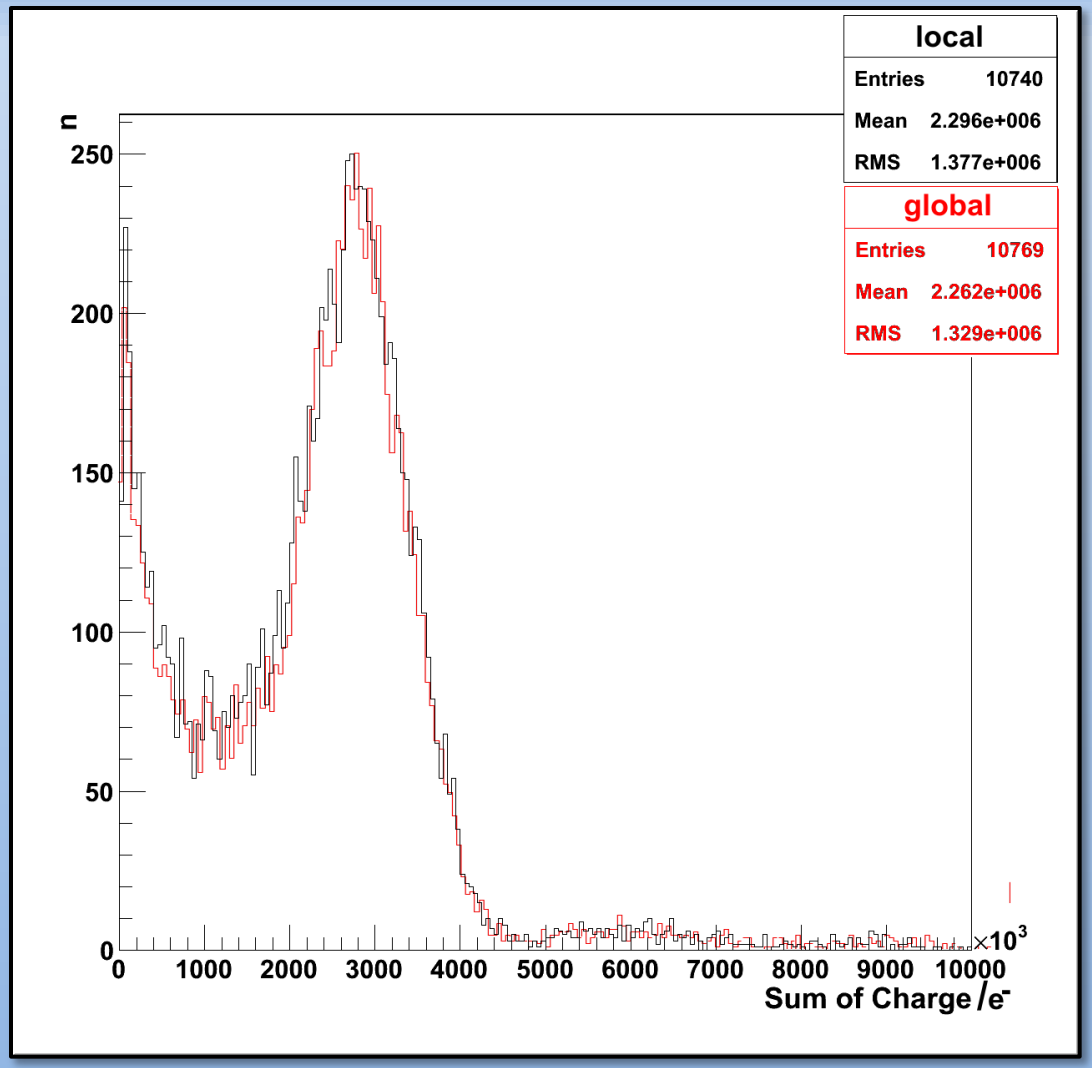
calibration with higher precission necessary

data: 1x1 metallized

Calibration: shape

reconstructed clusters with
global (same scaling for all pixels)
and **local charge calibration**

→ *Shape* of cluster-TOT spectrum
is not changed by charge calibration



data: 1x1 metallized
GEM voltage 375 V

Test chamber

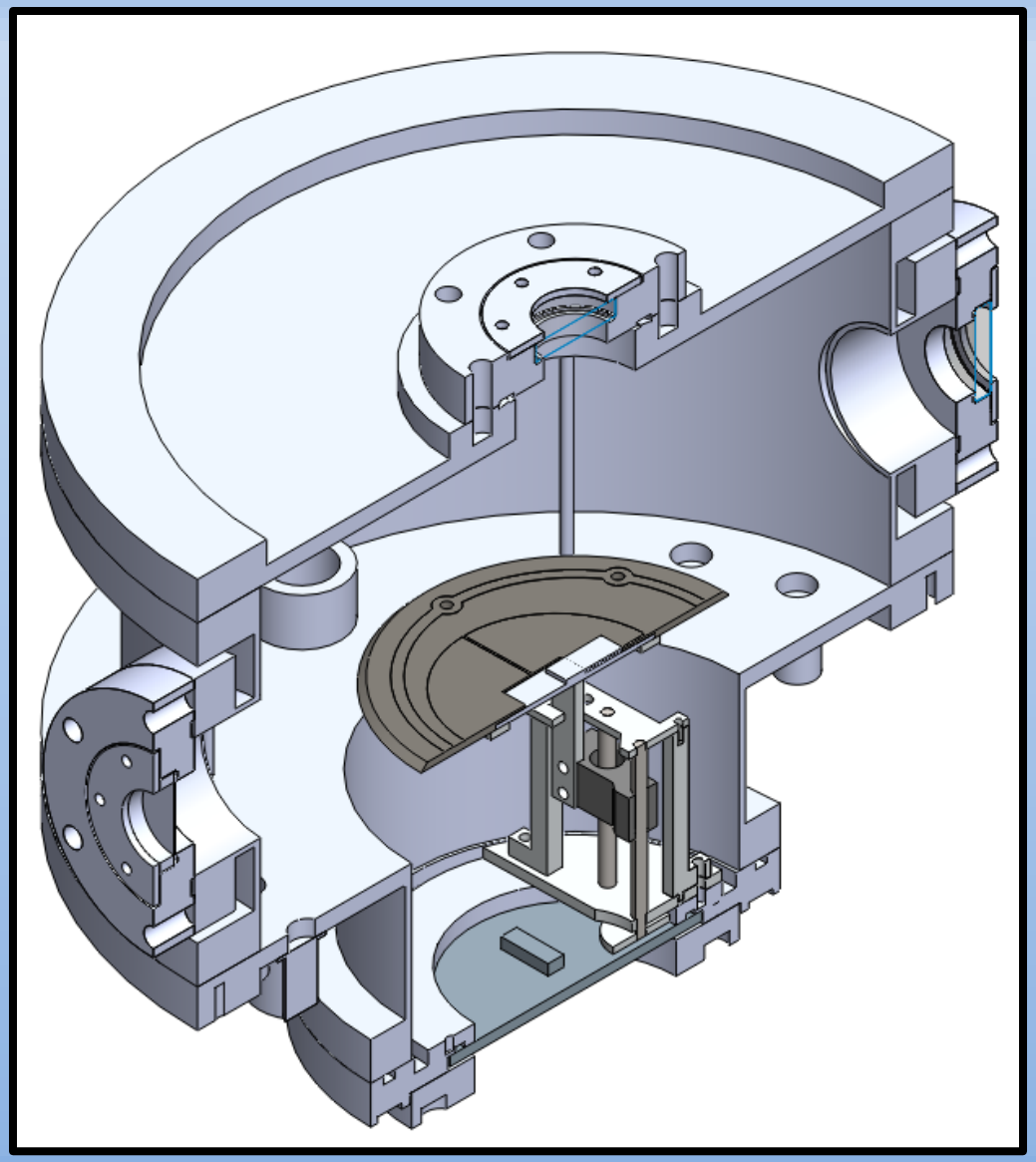
Goals

- modular construction
- non magnetic materials
- gas-tight

- GEM (mit 12x12 cm^2) incl.
  - readout electronics
  - HV

- experiments with:
  - N_2-laser
  - testbeam
  - radioaktive source

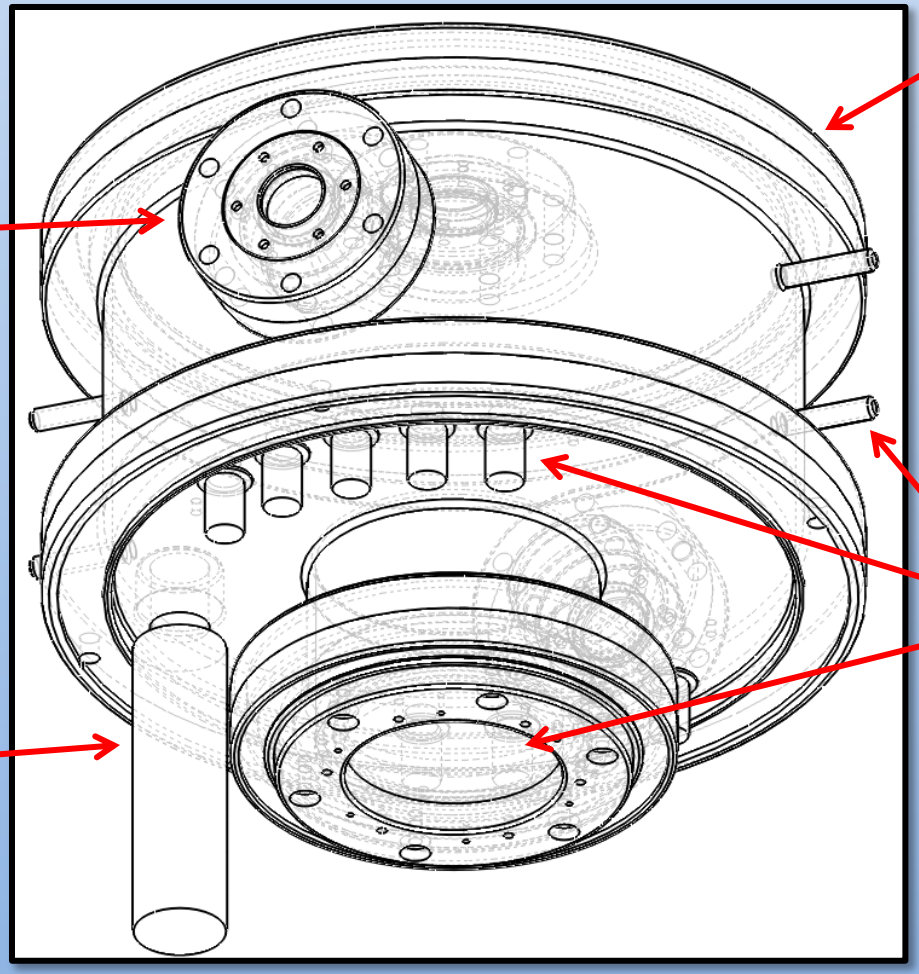
- simple exchange of TimePix chips



Test chamber

test chamber for gaseous detectors with max. 12x12 cm²

windows:
- optical [plexiglas]
- laser [quarz]
- testbeam [Al]



Iso-K system

connections:
- gas in- /outlets
- SHV plugs (GEM)
- elektronics (board)

sensors:
- pressure (+/- 0,5 mbar)
- temperatur e(+/- 0,5 K)
- (humidity)

Summary

Σ

- pixel enlargement reduces necessary gain
- cross-talking (at high voltages) does not depend on deposited charge
- pixelwise calibration could improve charge reconstruction
- USB-interface(1.2.2) should not be used for calibration
- a new test chamber has been developed

Ω

- more studies in calibration with test pulses
- comparison of postprozessed chips (n x n) in respect to:
  - gas amplification
  - spatial resolution
  - detection efficiency

The TimePix chip 2006

A modified MediPix2 Chip for TPC applications

Motivation:

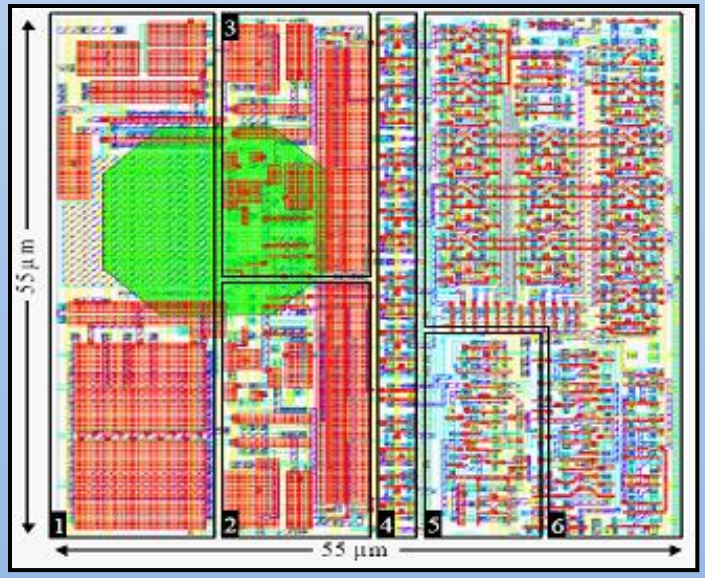
knowing the time of arrival of avalanches at pixels

⇒ use 14bits counter not for counting the #hits, but for counting clock cycles

- (only lower threshold)
- clock up to 100 MHz in each pixel
- threshold (whole chip): ≈ 700 e^-
- 4 different modes possible

  modes definable for every pixel
  using a "*map*"

TPC-Setup:
- use Time-arrival mode
- use TOT for calculating charge



TimePix chip with active area (green)

The TimePix chip 2006

TimePix Modes