Large-Area Floating Strip Micromegas Detectors

LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

J. Bortfeldt, O. Biebel, R. Hertenberger,
P. Lösel, S. Moll, A. Zibell

LS Schaile
LMU Munich

FLOATING STRIP PRINCIPLE

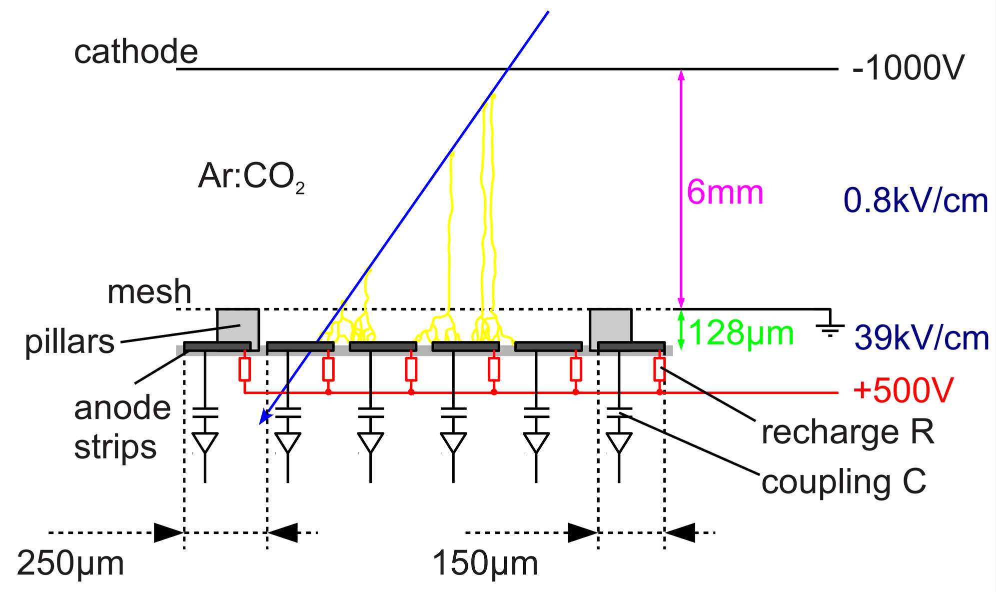
motivation: discharges in Micromegas between mesh and strips
- cannot be avoided
- are non-destructive
- create dead time due to recharge time

goal: suppress discharges quickly to avoid complete voltage drop

novel "floating strip" concept:
"floating" copper anode strips:
- individually attached to HV via ~20MΩ
- capacitively coupled to electronics with ~50pF capacitors

→ potential discharge affects only 1-2 strips
→ fast recovery, no charge up, no aging expected

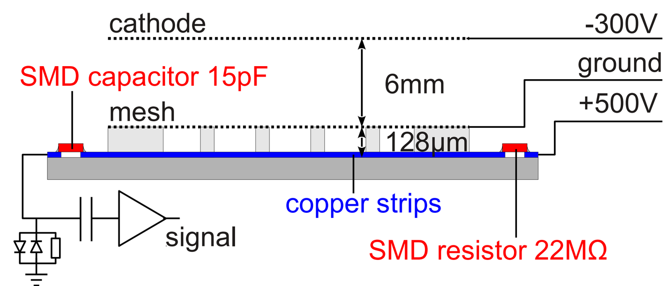
impact of discharges on efficiency and spatial resolution can be significantly reduced



see also: A. Bay, I. Giomataris et al., Nucl.Instrum.Meth. A488:162-174, 2002

FLOATING STRIP MICROMEGAS REALIZATION

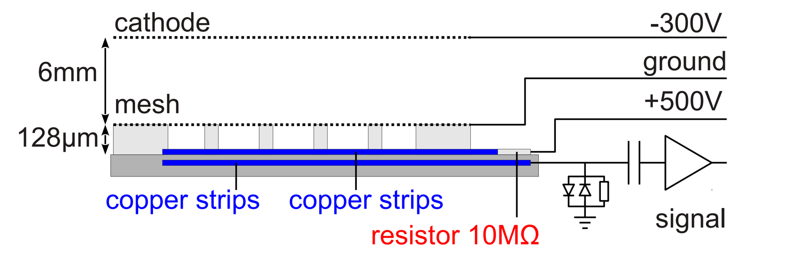
"discrete" solution



idea:
- copper anode strips on +HV via exchangeable SMD resistors
- decouple signal via exchangeable SMD capacitors

several prototypes:
- 6.4 x 6.4 cm² active area, 128 copper strips, 500μm pitch, 300μm width
- amplification gap: 128μm
- drift region: 6mm
- gas: Ar:CO_2 93:7 @ 1013mbar

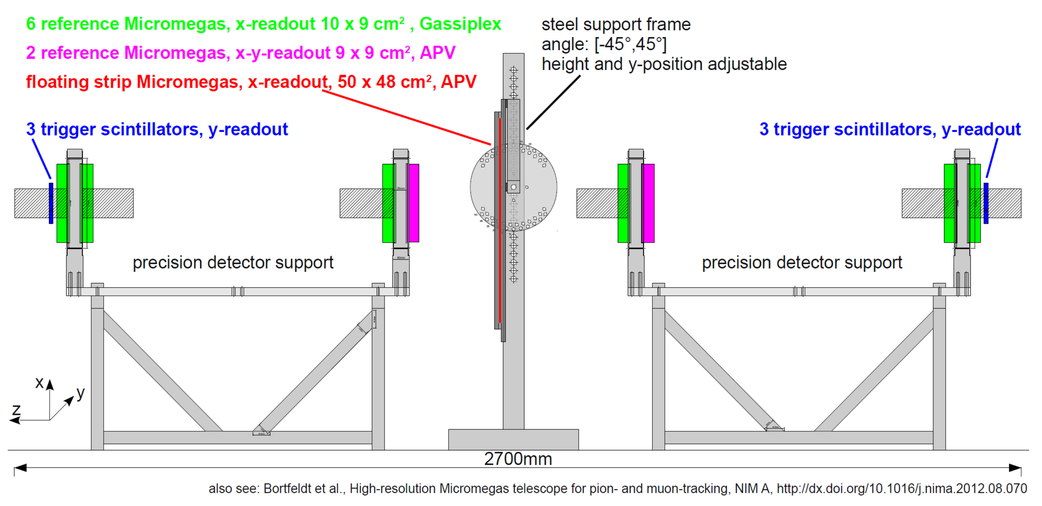
"integrated" solution

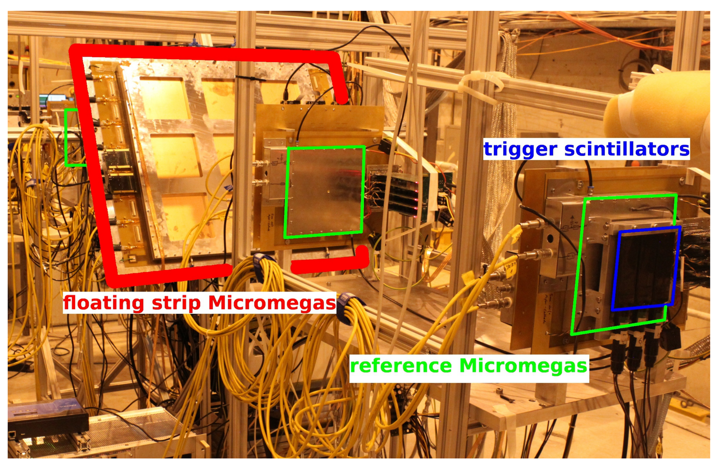


idea:
- copper anode strips on +HV via resistor paste
- below these, capacitively coupled copper readout strips to collect signal

prototype:
- **50 x 48 cm² active area**, 1920 copper strips, 250μm pitch, 150μm width
- amplification gap: 128μm
- drift region: 6mm
- gas: Ar:CO_2 93:7 @ 1013mbar

PION TEST BEAM SETUP @ H6 SPS / CERN



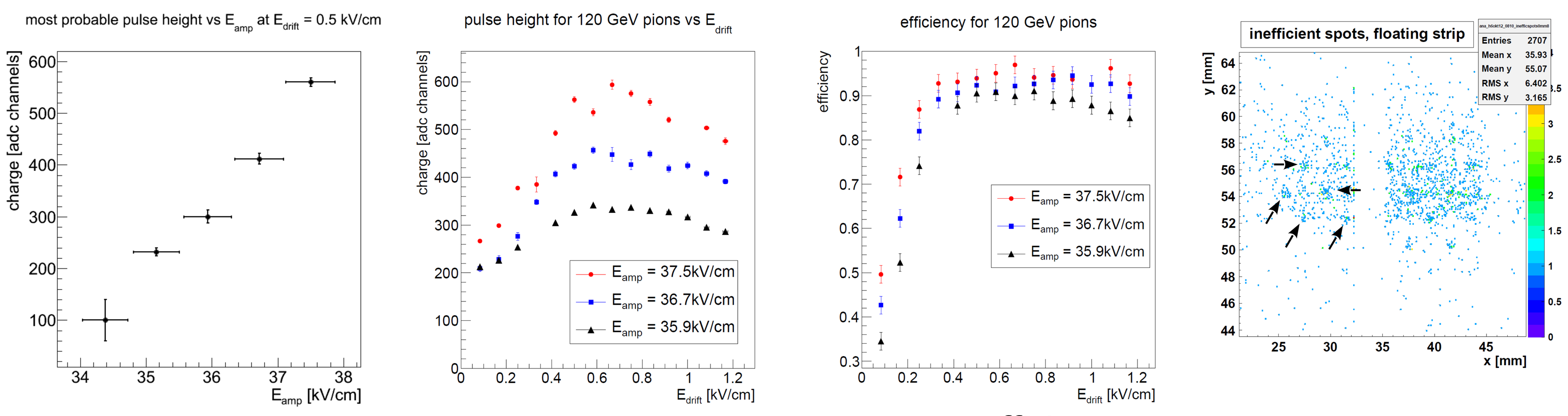


test beam October-December 2012:
- pions: 10 – 160GeV
- hit rates: 0.1 – 75kHz/cm² adjustable
- muons

- **floating strip Micromegas**: 50 x 48 cm² active area, x-y-scan, angular scan, readout: Scalable Readout System with APV25

- **tracking telescope**:
  - six non resistive Micromegas, active area 10 x 9cm², 360 strips, Gassiplex readout (VME)
  - two resistive Micromegas, active area 9 x 9cm², 2d-readout, 2x358 anode strips, Scalable Readout System
  - two scintillator layers, active area 10 x 10cm², 3 scintillators per layer, VME readout (TDC)

PULSE HEIGHT & EFFICIENCY OPTIMIZATION



pulse height vs. E_{amp}
exponential rise as expected, can be selected according to requirements over wide range of gas gain.

pulse height vs. E_{drift}
low E_{drift}:
- poor charge separation
- attachment

high E_{drift}:
- decreasing electron transparency of mesh

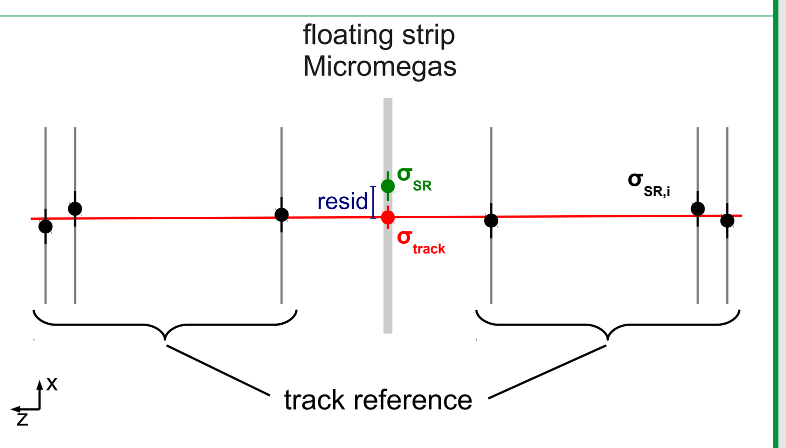
efficiency vs. E_{drift}
- between 95% and 97% for 0.4kV/cm < E_{drift} < 1kV/cm for 120GeV pions
- mesh supporting pillars create most of the inefficiency

SPATIAL RESOLUTION FOR 120 GEV PIONS AT PERPENDICULAR INCIDENCE

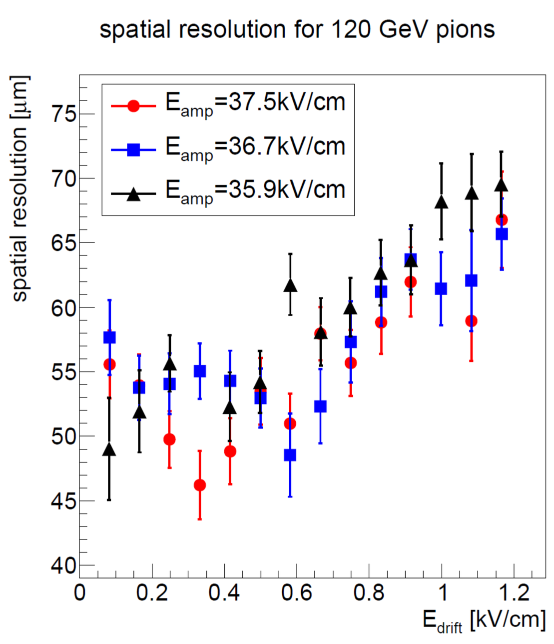
calibration of single detector spatial resolution $\sigma_{SR,i}$ in the reference detectors:

- calibration of the i-th detector:
  - $\sigma_{ex,i}$: reference detector under study not included in track fit
    → residual too large
  - $\sigma_{in,i}$: all reference detectors included in track fit
    → residual too small
- NIM A 538, 372: $\sigma_{SR,i} = \sqrt{\sigma_{in,i} \times \sigma_{ex,i}}$ for i = 1, … , 8

result: track resolution σ_{track} **= (18±3)μm** at position of floating strip Micromegas



the dots refer to a single event, error bars are given by spatial and track resolution respectively



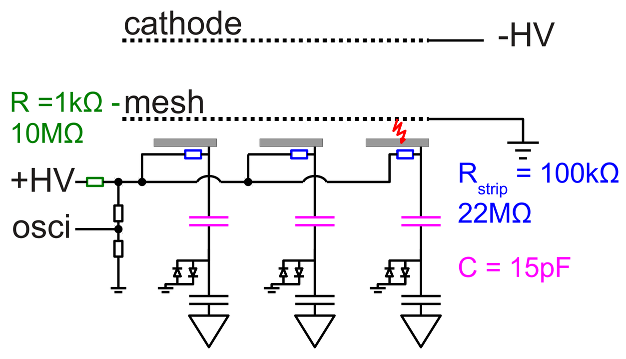
application: investigate spatial resolution σ_{SR} of floating strip Micromegas for varying operational parameters:

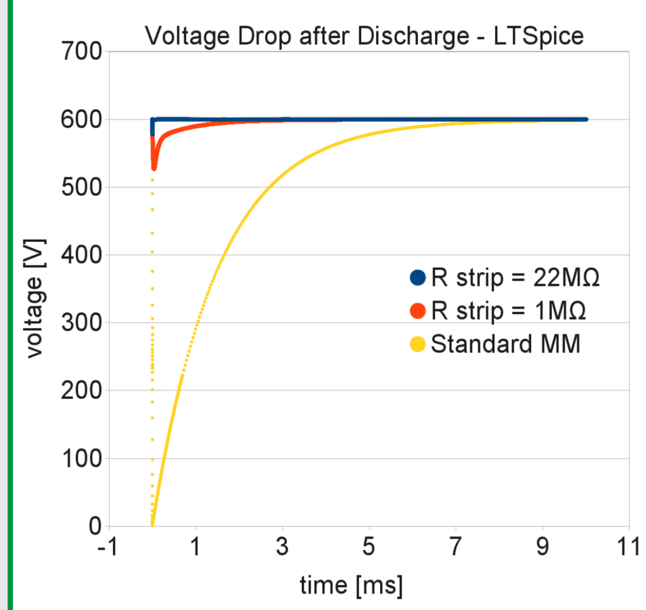
- interpolate track prediction from reference detectors with known resolution into the floating strip detector
- measure residual σ_{ex} (floating strip Micromegas not in fit) under different operational conditions

→ spatial resolution of floating strip Micromegas $\sigma_{SR} = \sqrt{\sigma_{ex}^2 - \sigma_{track}^2}$

optimum: σ_{SR} **= (46±3)μm**

VOLTAGE DROP AFTER DISCHARGE – SIMULATION & MEASUREMENT

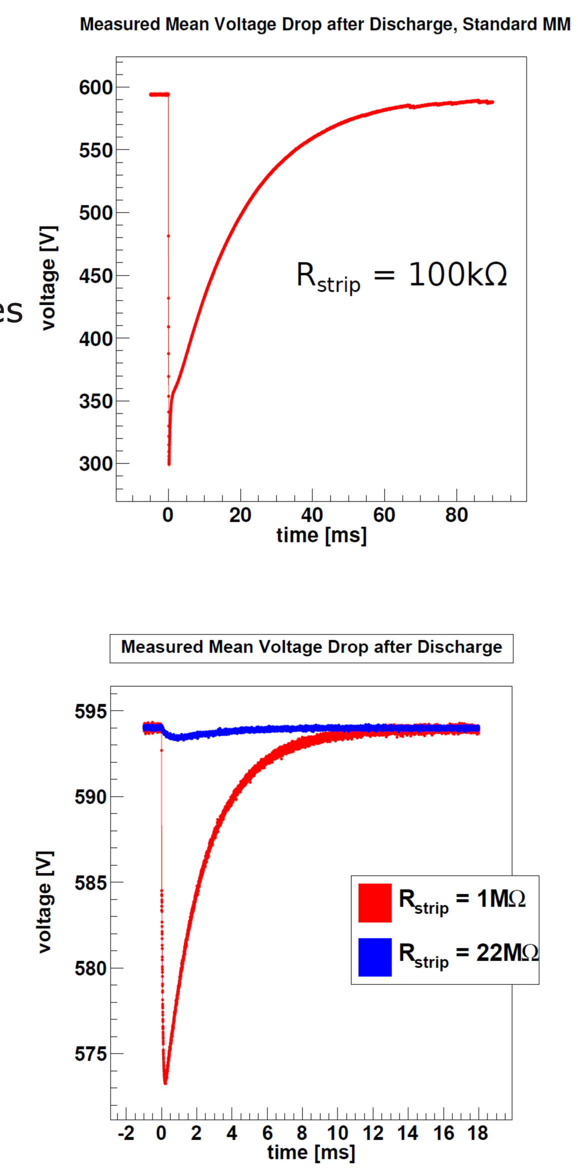




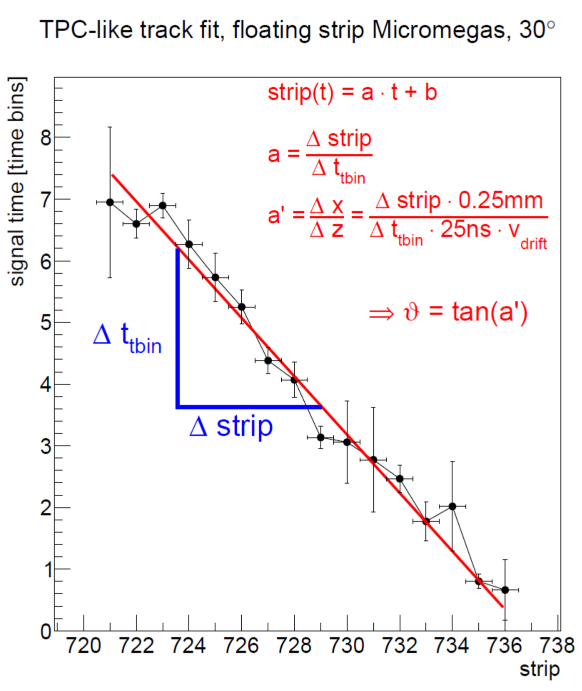
- create discharges in small floating strip detector with mixed nuclide alpha source
- measure global voltage drop
  → affects all strips
- measure signal on single strips
  → position of discharge
- LTSpice simulation of discharges in qualitative agreement with measurements

standard Micromegas:
- 100kΩ strip resistance (corresponds to standard Micromegas configuration)
- complete discharge of mesh onto strips
- whole detector affected
- ~60ms recharge time

floating strip Micromegas:
- 1MΩ strip resistance:
  - 30V voltage drop
  - ~10ms recharge time
- 22MΩ strip resistance:
  - 0.5V voltage drop
  - ~2ms recharge time
- → **drop completely negligible**

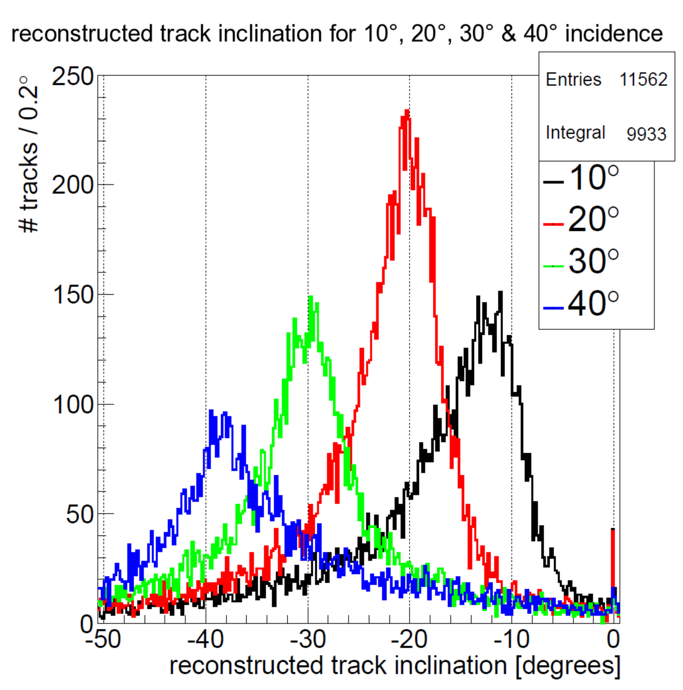


MICRO-TPC MODE OR SINGLE PLANE ANGULAR RESOLUTION



non-perpendicular tracks:
- measure arrival time of single charge clusters on strips
- clusters, created close to mesh, arrive instantaneously at strips
- clusters, created close to the cathode, arrive ~150ns later
- fit time with straight line
- directly determine track inclination from line fit with known electron drift velocity

→ **single plane angular resolution O(5°)**



SUMMARY

novel floating strip Micromegas with an active area of 50 x 48cm² and 6.4 x 6.4cm² have been developed
- anode strips are coupled individually to HV
- signals are extracted by capacitively coupled readout strips

measurements with **pion beams** at H6/CERN:
- **setup**: tracking telescope with six 10 x 9cm² non-resistive and two 9 x 9cm² resistive Micromegas + floating strip Micromegas
- **combined readout** of **Gassiplex** system (reference detectors) and **Scalable Readout System** (resistive and floating strip Micromegas) with reliable offline synchronization
- pulse height spectra, gas gain and mesh electron transparency behave as expected
- **homogeneous gas amplification**, variation ~ 15%
- **efficiency** for 120GeV pions ~97%
- **spatial resolution** at perpendicular incidence σ_{SR} = (46±3)μm
- single plane **angular resolution** O(5°)

discharge measurements with **5MeV alpha particles** in a 6.4 x 6.4cm² floating strip detector
- **setup**: measure global voltage drop on whole detector and signal on single strips
- **standard Micromegas configuration**: voltage drop 300V, recharge time 60ms
- **floating strip configuration**: voltage drop 0.5V, recharge time 2ms

→ **impact of discharges on performance is massively reduced**