Science Week 2014 Dec 1 – 4

RESEARCH AREA: B

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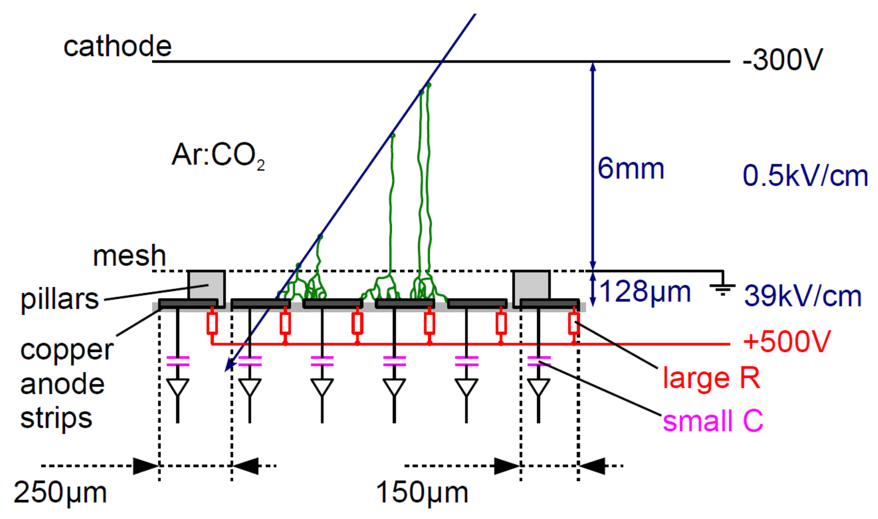
Three-Dimensional Particle Tracking with Micromegas at Highest Rates

FLOATING STRIP MICROMEGAS DETECTOR

functional principle
- charged particles
  → ionization
- gas amplification 10^3
- charge signal on strips
  single strip readout
  → spatial resolution O(50µm)
  → timing O(ns)
- thin amplification region & fine segmentation
  → fast drain of positive ions
  → high rate capable

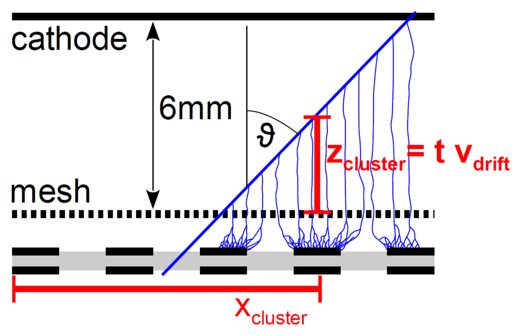


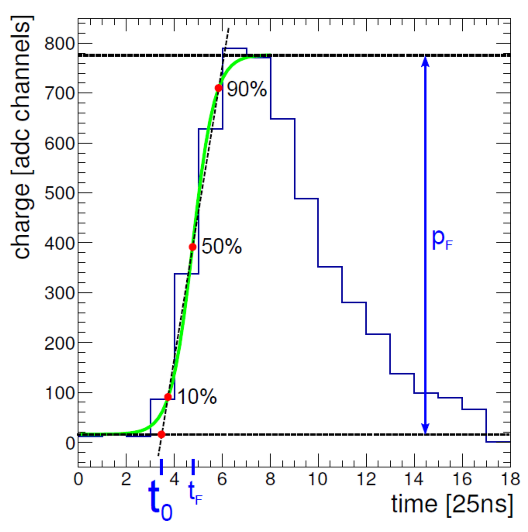
challenge: discharges
- charge density ≥ $2 \cdot 10^6$ e/0.01mm²
  → streamer development
- conductive channel between mesh & anode
  → potentials equalize
- non-destructive, but dead time
  → efficiency drop, especially at high particle rates

solution: floating strip Micromegas
- strip individually connected to HV via 22MΩ resistors
- readout electronics coupled via pF capacitors

→ strips can "float" in a discharge
→ only one to three strips affected
→ fast recovery

µTPC RECONSTRUCTION METHOD



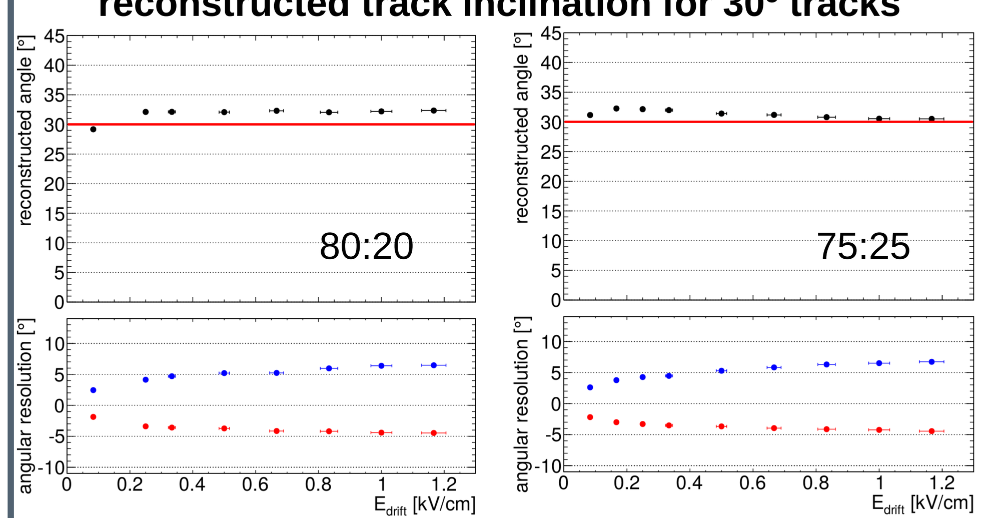


method
- electron arrival time ⇔ drift distance
- measure signal timing
  → arrival time of charge cluster on strip
- linear fit to time-strip data points:
  $t(s) = a\,s + t_0$
  → track inclination:
  $\vartheta = \tan^{-1}\left(\frac{p_s}{a\,v_d\,25ns}\right)$ with p_s = strip pitch
  → alternative hit position

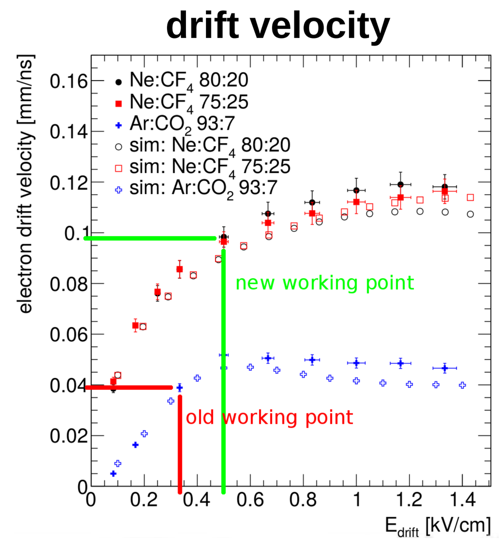
systematics
- reconstructed track inclination too large
- capacitive coupling of signals onto neighboring strips
- simulation with parameter-free LTSpice detector model
  → calibration possible

µTPC RECONSTRUCTION WITH Ne:CF_4

reconstructed track inclination for 30° tracks



drift velocity



- single plane track inclination reconstruction possible with fast Ne:CF_4 mixtures
- angular resolution $\left(^{+5°}_{-4°}\right)$ for E_{drift} ≤ 0.6kV/cm

ACKNOWLEDGMENTS

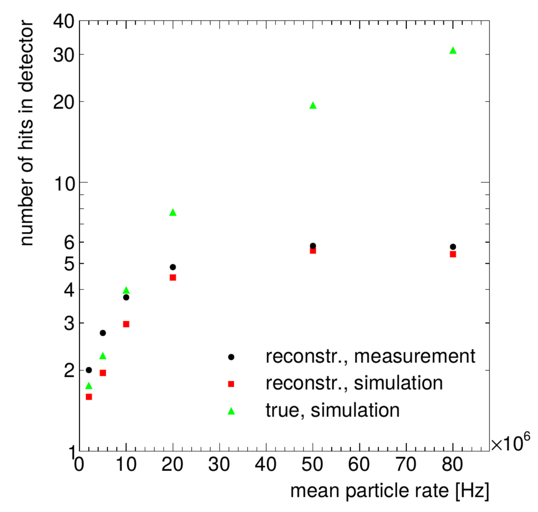
This research was supported as a seed project by the DFG cluster of excellence "Origin and Structure of the Universe"

IMPROVING HIGH-RATE CAPABILITY

shorter signals
- signal duration: maximum electron drift time (cathode to mesh) + maximum ion drift time (anode to mesh)
  → light base gas: Ne instead of Ar
  → fast admixture gas: CF_4 instead of CO_2

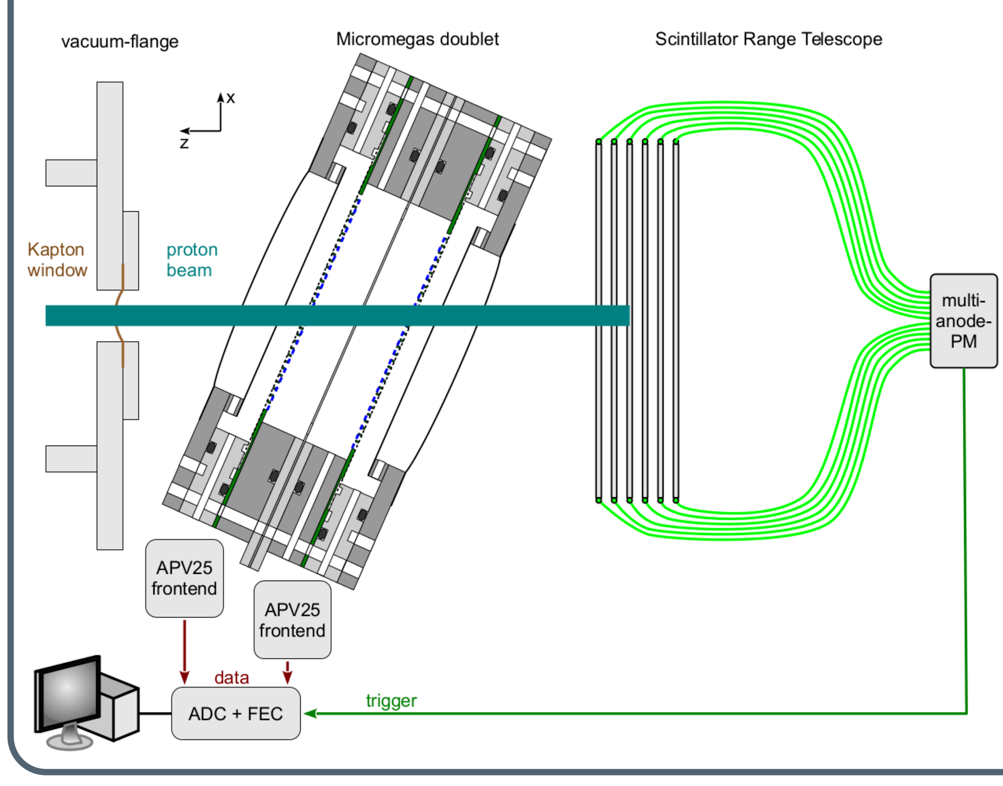
finer segmentation
- pixels
  → intermediate: two-dimensional readout plane with crossed x- and y-strips

faster readout electronics
- fast shaping
- online data filtering
- high-readout speed



up to now: complete particle separation at 7MHz/cm², single particle tracking up to 60MHz/cm²

TEST BEAM: 23MeV p & Ne:CF_4 GAS @ TANDEM

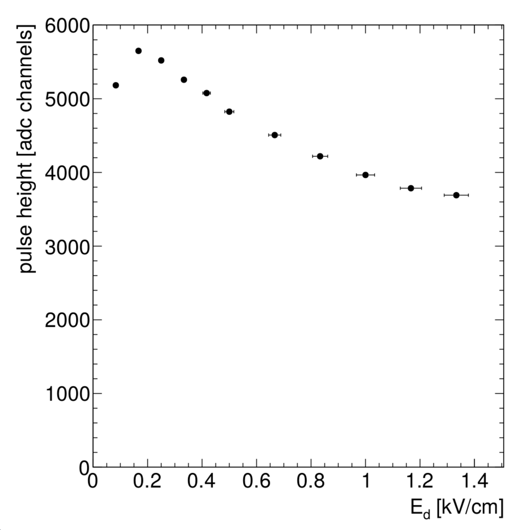


floating strip Micromegas doublet
- two detectors back-to-back
- 6.4 x 6.4 cm² active area
- 128 strips / detector, 0.5mm pitch
- low material budget
  (FR4 + Cu ≤ 200µm)

beam
- 23MeV protons

gas mixture
- Ne:CF_4 80:20 & 75:15 @ 980mbar
- investigate mesh transparency, gas gain, detection efficiency
- measure electron drift velocity

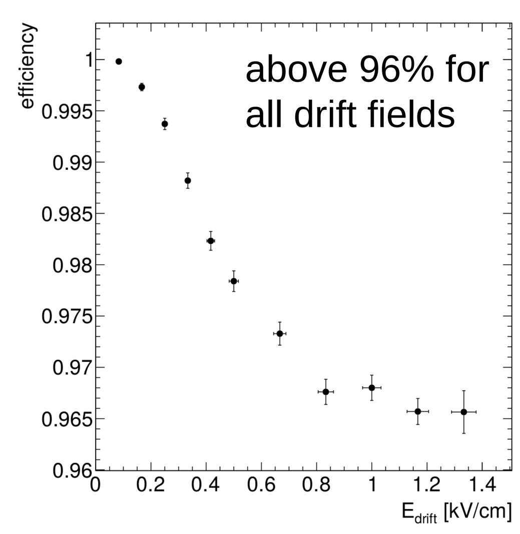
PULSE HEIGHT & EFFICIENCY WITH Ne:CF_4 80:20



pulse height

low E_{drift}
- low charge separation
- low drift velocity

large E_{drift}
- low electron mesh transparency



SUMMARY & OUTLOOK

high-rate capability improved
- fast Ne:CF_4 gas
- efficiency and pulse height behavior as desired
- electron drift time 150ns → 60ns
  ion drift time 260ns → 85ns
  → factor 3 in signal duration

ultra-thin floating strip Micromegas
- two-dimensional strip readout
- 3 x 35µm Cu + 2 x 25µm Kapton
- readout PCBs available next week
- allows for 3d track reconstruction in a single detector

floating pixel Micromegas
- if two-dimensional FSM works
- estimated: full particle separation at >30MHz/cm²