Recent progress towards a Pixel-TPC

K. Desch • Bonn University • 19/10/2006

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1. Objectives
2. New Structures (Ingrid,Twingrid,…) + Discharge Protection
3. Gas Studies
4. Testbeam at DESY (Medipix+3GEM)
5. Simulations
6. Summary and Plans

Participating Institutes:
BONN BUCHAREST CERN DAPNIA-CEA FREIBURG NIKHEF

(this talk: everything except Timepix)

1. Objectives

Idea: use a Pixel readout chip (w/o Si sensor) as integrated device hosting pads + readout electronics for a TPC

Potential Advantages:

- very small (50x50 μm2) Pads
- potentially very good point+momentum resolution
- dE/dx via cluster counting
- frontend electronics automatically integrated ('active endplate')

SiTPC goals in EUDET:

- construction and test of the Timepix chip (CERN μ-Electronics team)

  ⇨ X.Llopart's talk

- construction of module(s) for LP endplate(s) for diagnostic puposes

both Micomegas and GEMs as gas amplification systems are beiing pursued

2. New Structures

NIKHEF

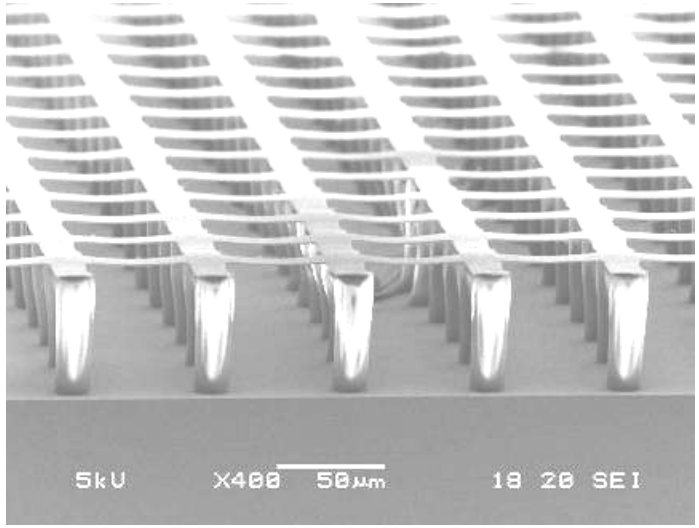
InGrid, an integrated Micromegas

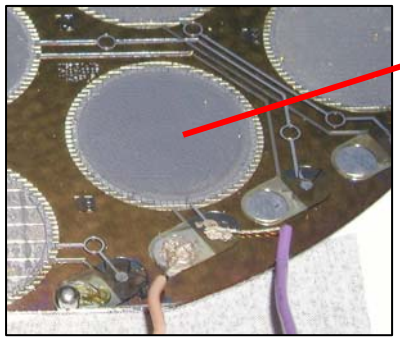
Integrate grid by wafer post processing

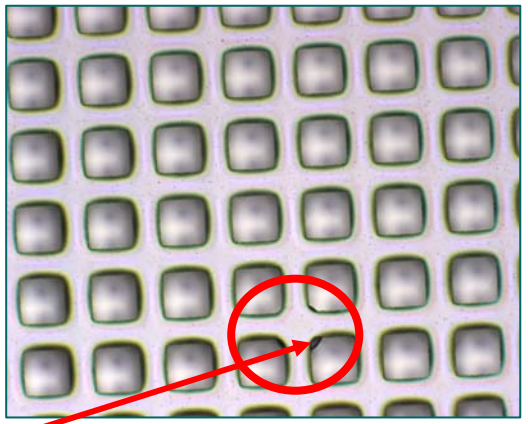
Low tempertaure process (spin coating, wet etching)

Perfect alignment between grid holes and pixel pads

No pillars dead areas - Flexible design





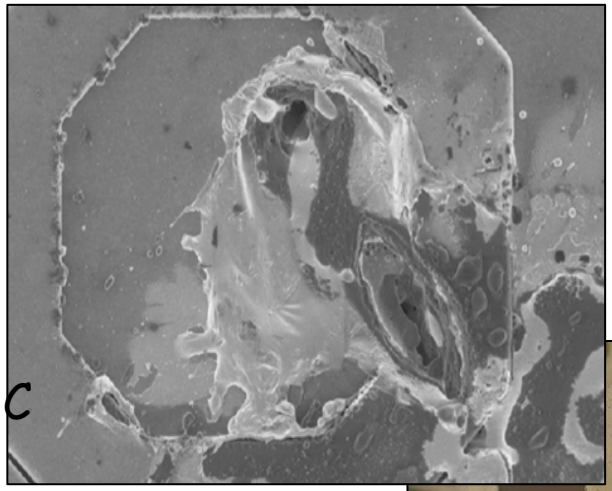


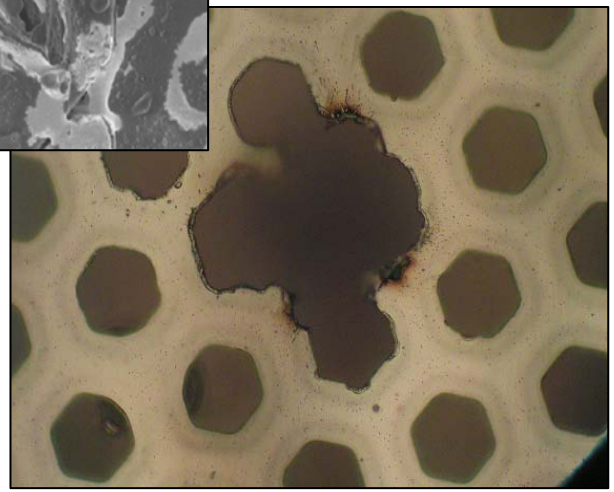
2. Discharge protection

NIKHEF

Discharges
- melt pixel pad
- damage Grid

1 µm thin grid
Aluminum Tf ~ 660 °C





Proposals:

Resistive layer, RPC principle

SiProt

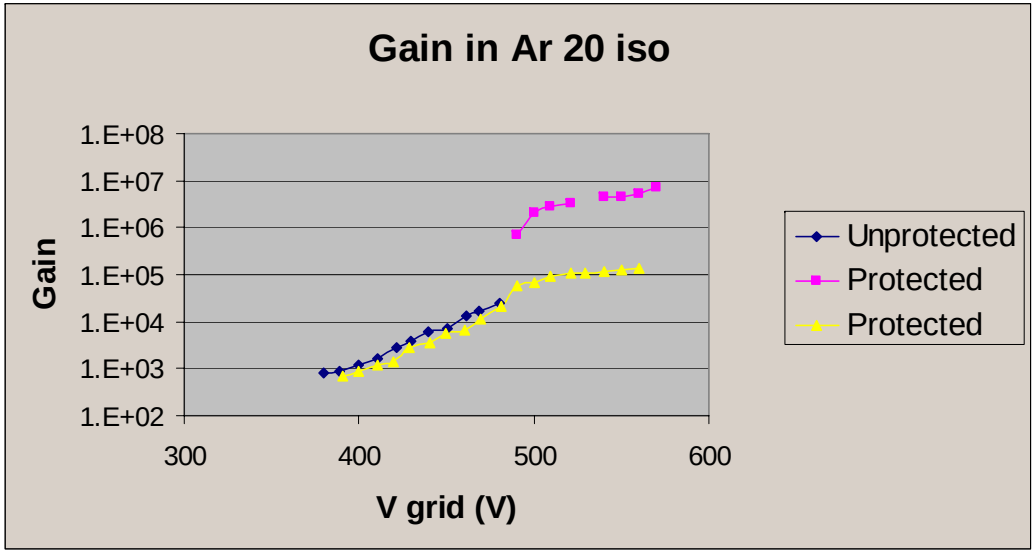
Multi-stage amplification

TwinGrid

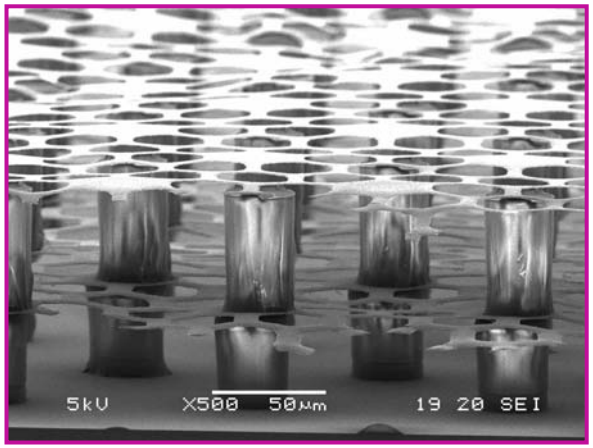
2. Discharge protection

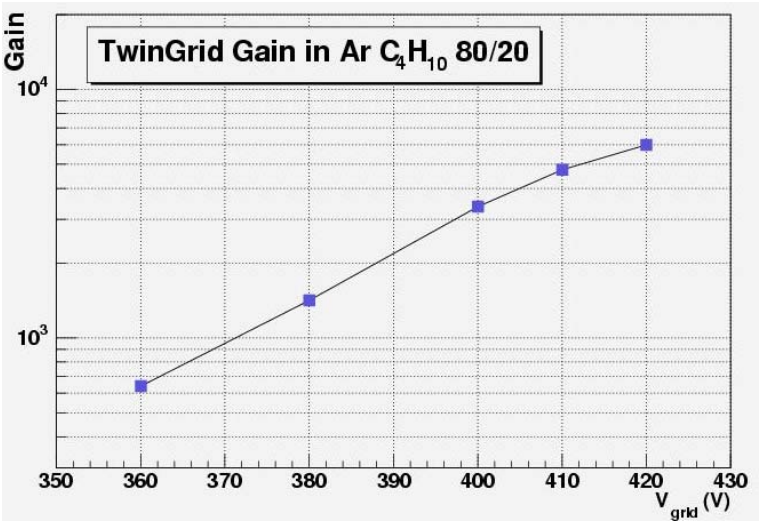
NIKHEF

First results from resistive layer:



First result from 2-stage amplification (Twingrid)





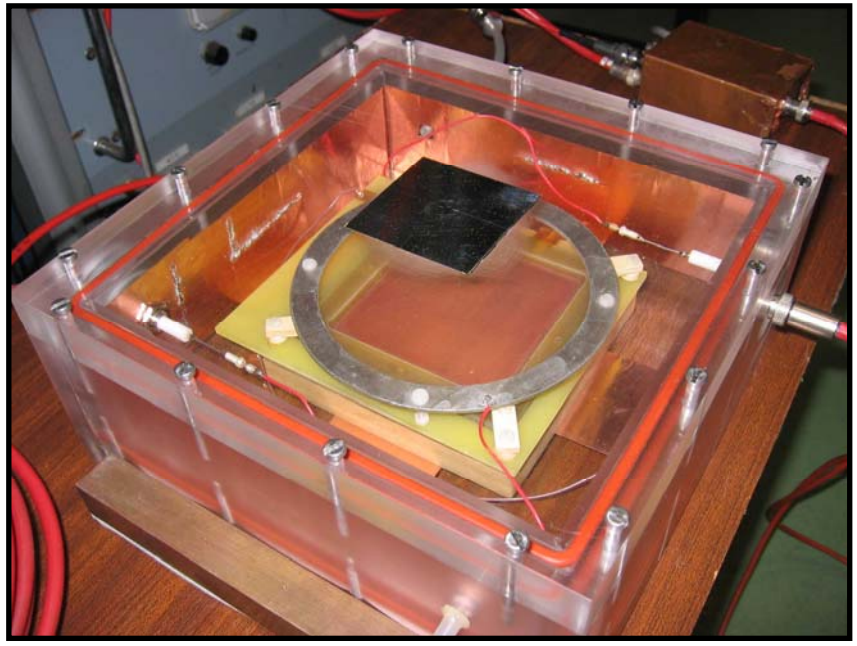
3. Gas Studies

Saclay

Complementary approach to fight the sparks in Micromegas structures:

- finding a gas mixture for optimal stability
  - damping the sparks (specific supply circuit)

Comprehensive study started



- "Standard" 50 μm mesh of 10 cm x 10 cm size

- Sources:
  - Fe 55 (5.9 keV)
  - COOL-X (8.1 keV)

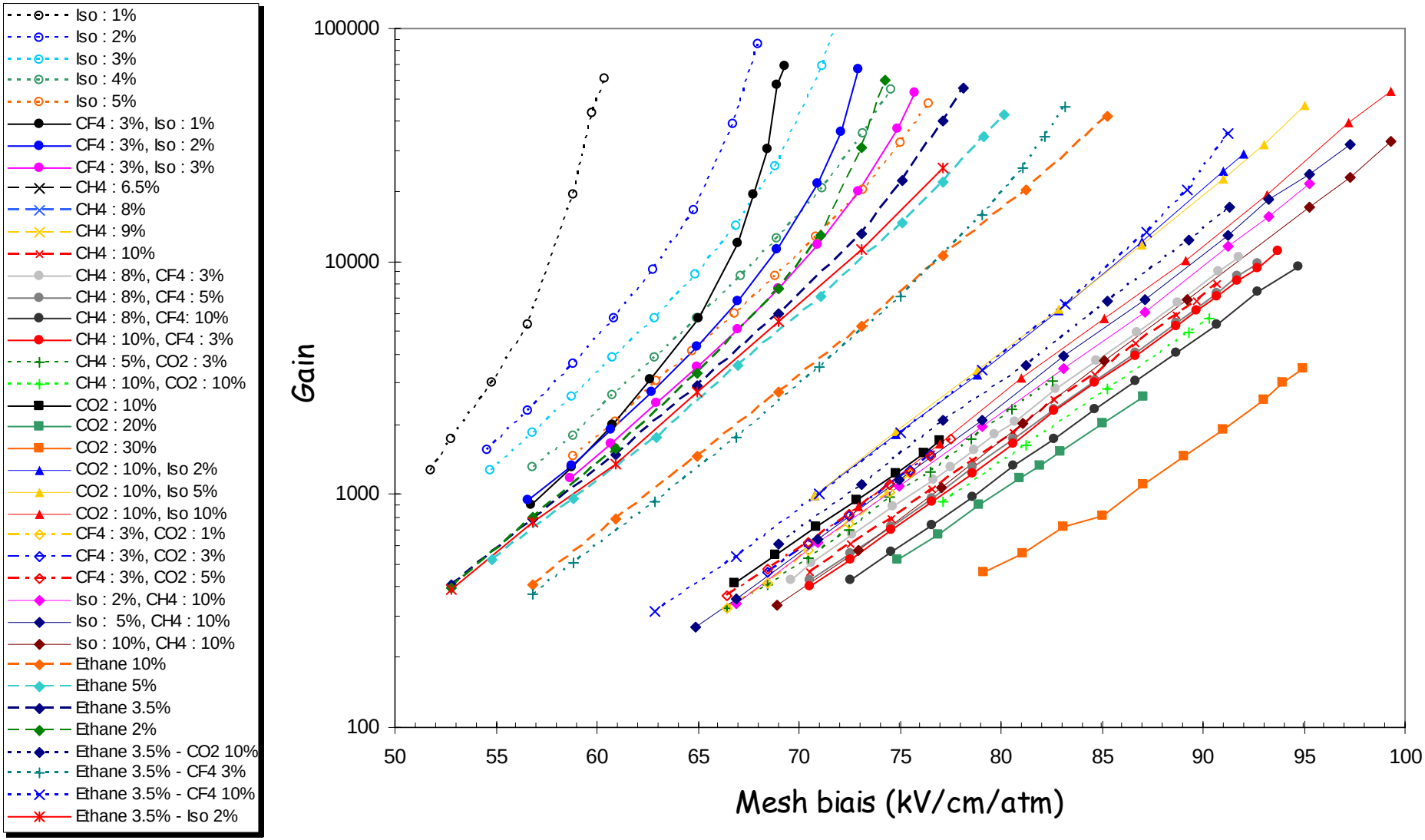
- Monitoring of:
  - pressure
  - H_2O

3. Gas Studies

Saclay

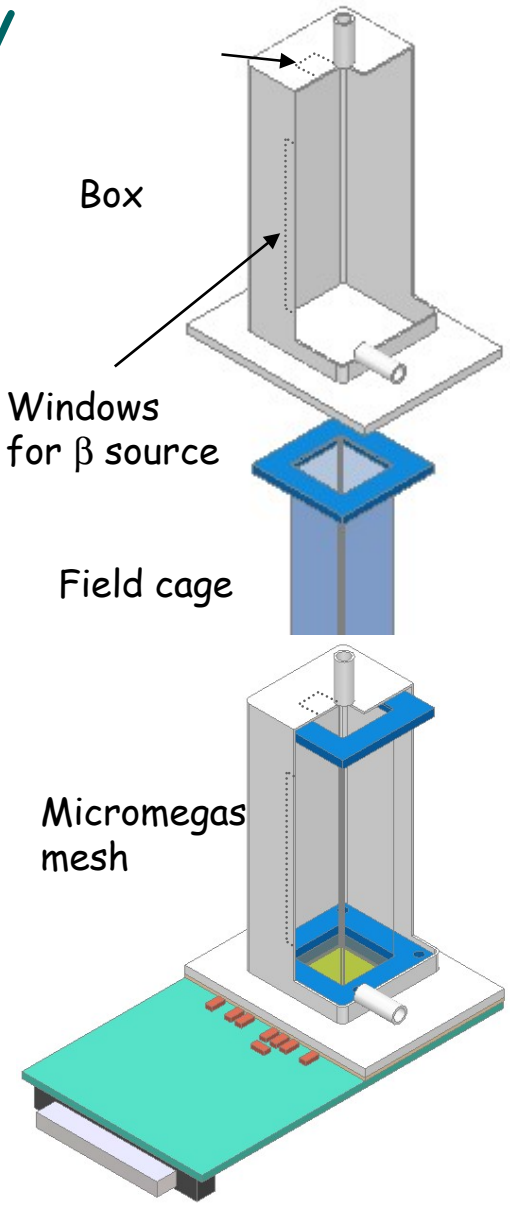
Mesh : 50 μm gap of 10x10 size

Mixtures of gases containing argon



3. Further activities at Saclay

- Study of detector-to-detector gain homogenei
- Measurement of ions backflow using various InGrid geometries
- We are ready to test TimePix in gas
- Future activities and development in Saclay
  - design for a Mini-chamber using Medipix2 readout chip
  - SiTPC endplate for the Large Prototype



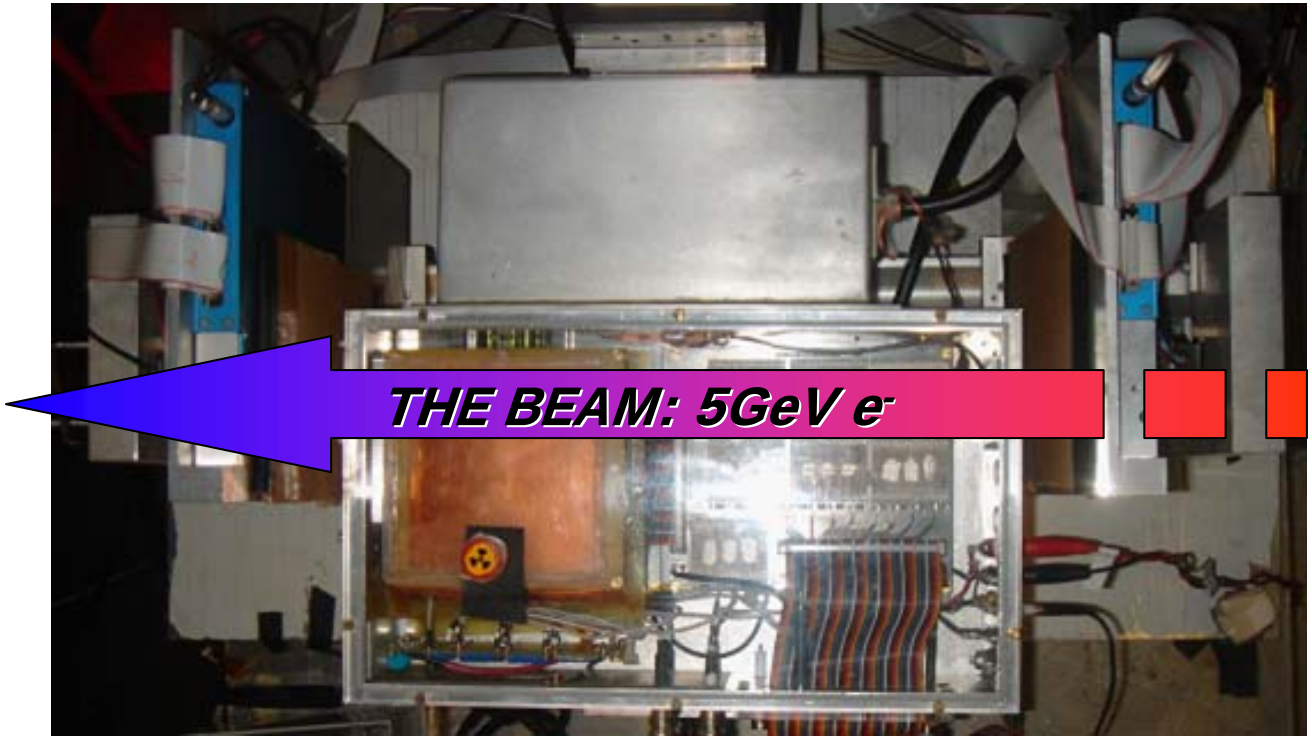
4. Testbeam at DESY: 3-GEM+Medipix

Freiburg
Bonn

4 weeks of beam test in September/October

Very good support from DESY testbeam support : thanks to N.Meyners et al!
Use ZEUS Silicon telescope: thanks to U.Kötz,I.Gregor,J.Stzuk!
Support of DESY FLC group : thanks to M.Janssen et al!
(NB: a pity that we were all German – would have been a nice TA1 usage, will organize at the European level next time…)

The setup:
(top view)



4. Testbeam at DESY: 3-GEM+Medipix

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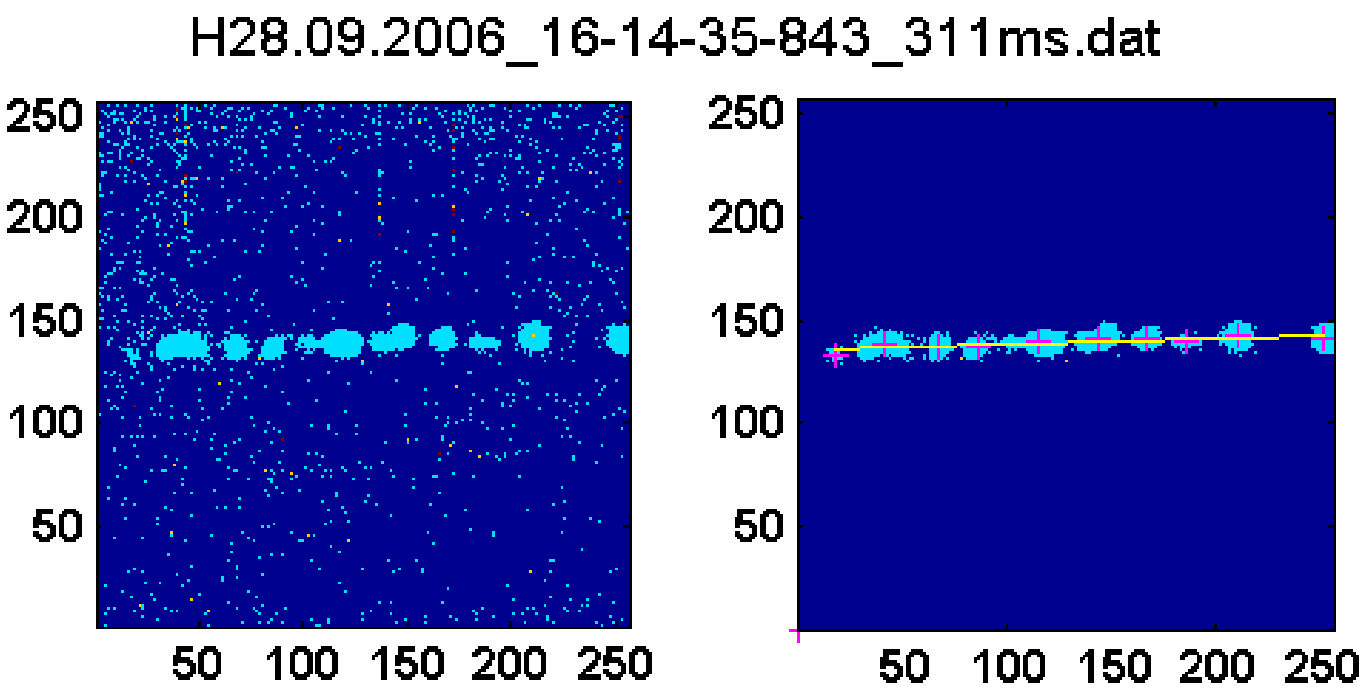
Typical events (have ~100.000 tracks on tape)



raw events

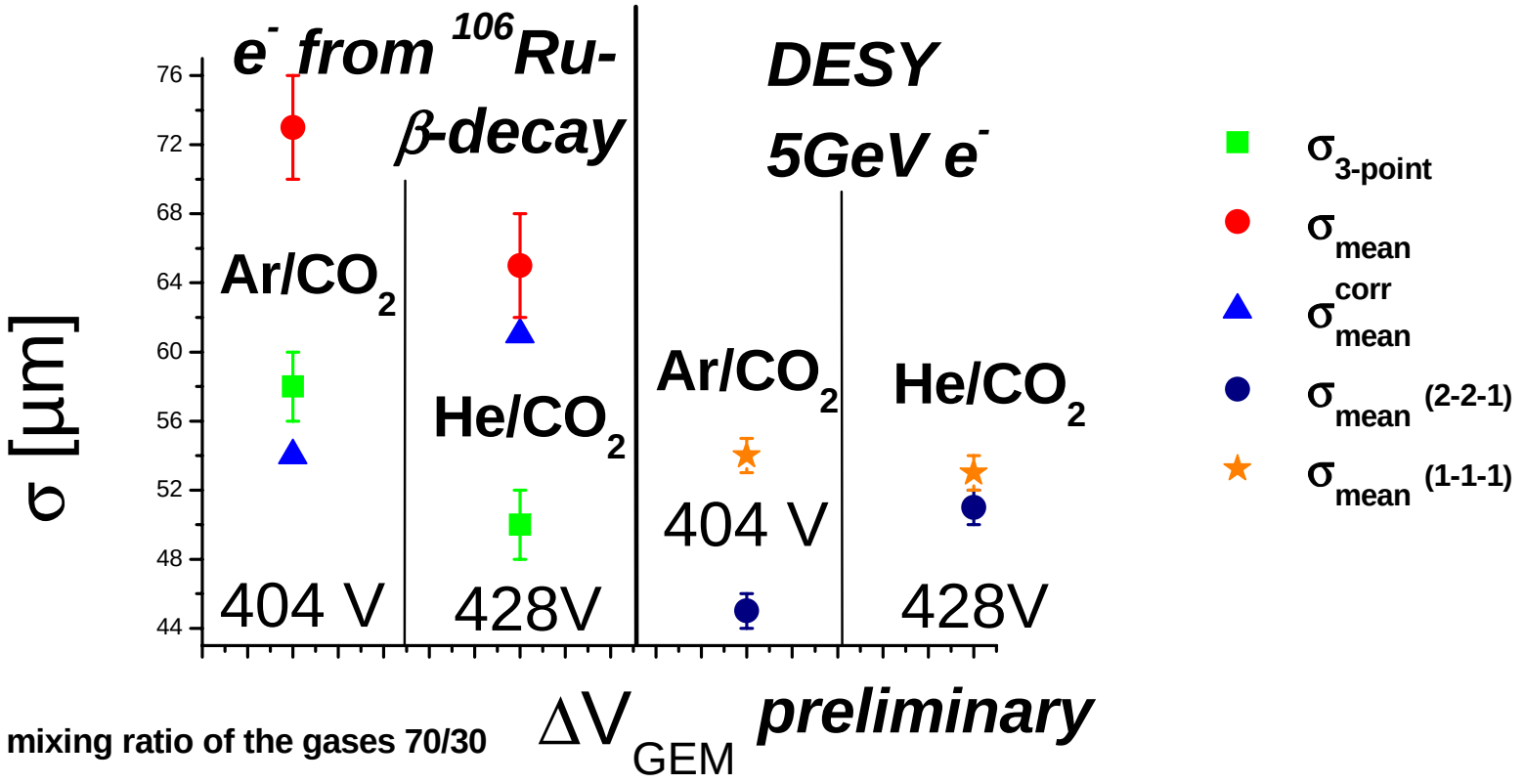
$ArCO_2$,
ΔV_{GEM}=404V

after some cleaning and cluster finding
(remove isolated pixels)

4. Testbeam at DESY: 3-GEM+Medipix

Freiburg
Bonn

Preliminary point resolutions (averaged over all drift distances)



Resolutions in testbeam consistent with mult.-scatt. corrected resolutions from ^{106}Ru (2 MeV e$^-$)

4. Testbeam at DESY: 3-GEM+Medipix

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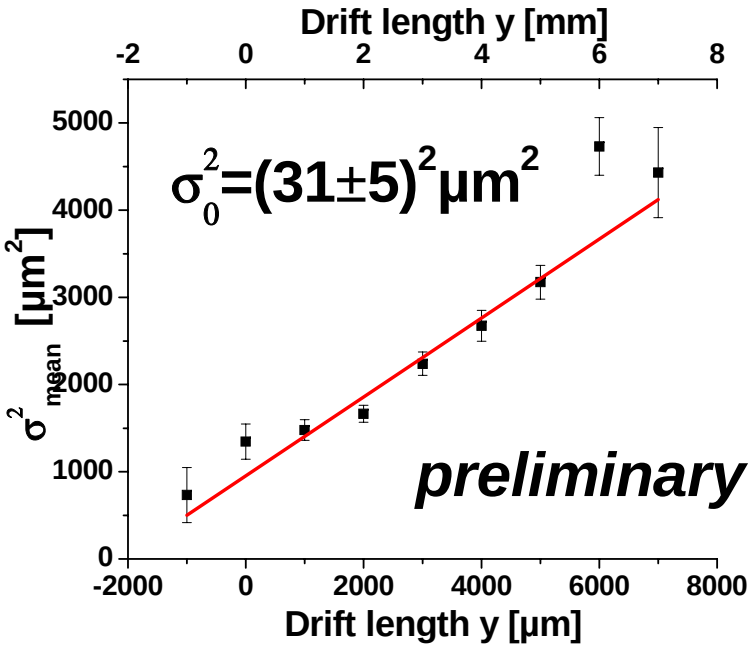
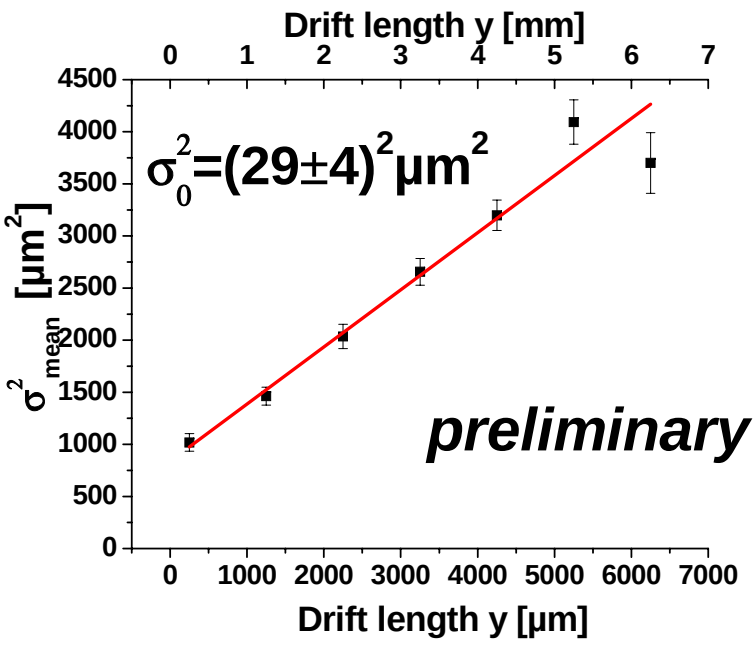
Preliminary point resolutions: as a function of drift distance:



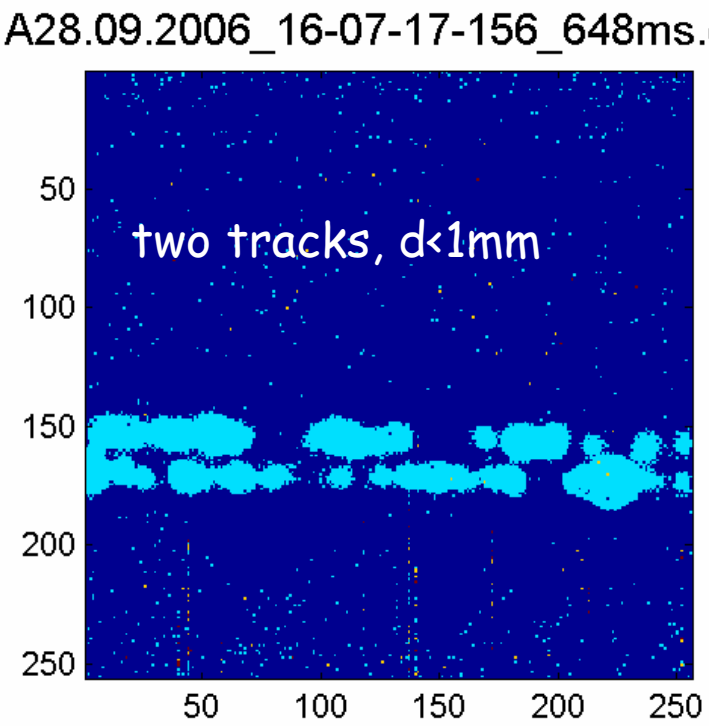


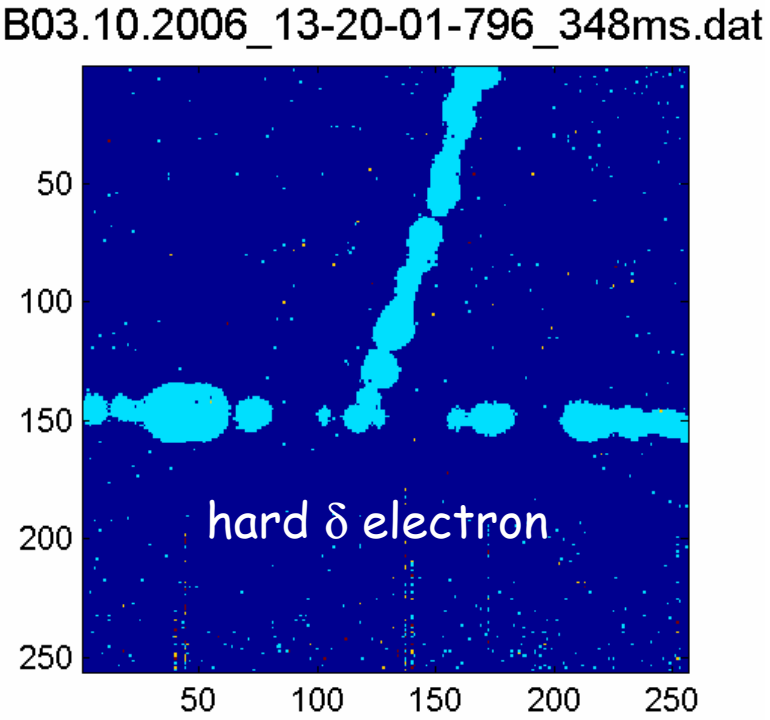
σ_0 ($ArCO_2$, 2-2-1) = 37±5 µm²

Lots of data to be analyzed
Still the same Medipix chip as 1.5 years ago
Prepare for Testbeam with Timepix in same setup a.s.a.p.

4. Testbeam at DESY: 3-GEM+Medipix

Freiburg
Bonn





Lots of data to be analyzed
Still the same Medipix chip as 1.5 years ago
Prepare for Testbeam with Timepix in same setup a.s.a.p.

5. Simulations for Testbeam

CLUSCO (M. Hauschild)

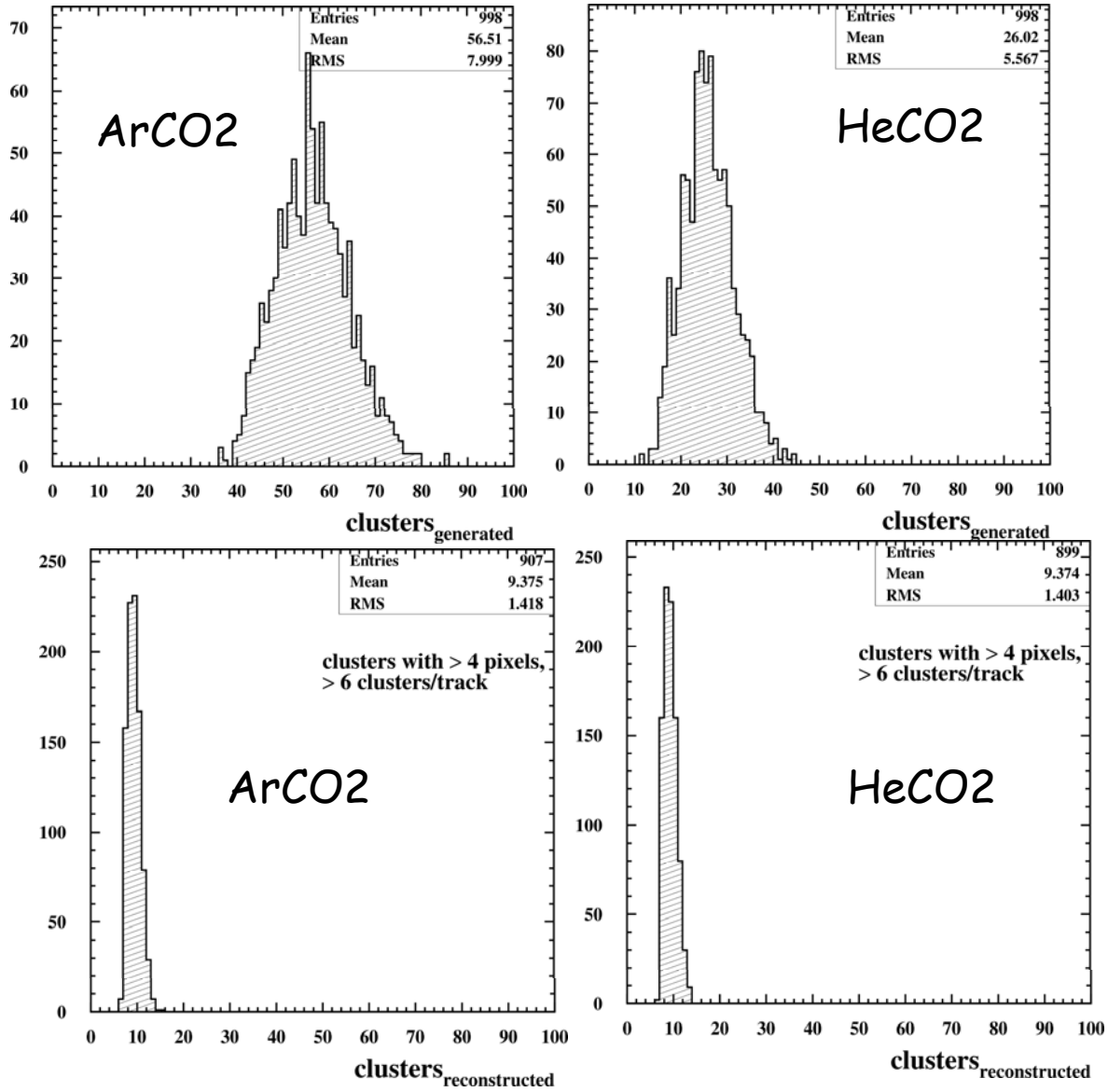
- Generates ionization clusters/electrons along tracks and drifts electrons towards GEMs/MicroMegas structures
  - HEED (I. Smirnov) for cluster generation (incl. δ-electrons, mult. scat.)
  - MAGBOLTZ (S. Biagi) for gas properties (diffusion, drift velocity)
- "Squeeze" electrons through GEM/MicroMegas holes and perform gas amplification
  - use simple geometric transformations, no detailed E-field simulation
  - exponential gas gain distribution
- Drift ALL electrons created in gas amplification to next GEM or MediPix (can be several Millions in total)
- Count electrons collected on MediPix, noise + apply detection thresholds (digitization step)

5. Simulations for Testbeam

Cluster densities:

- Very different primary cluster density
  - Ar/CO2 (70/30): 40.0cl./cm
  - He/CO2 (70/30): 18.4 cl./cm

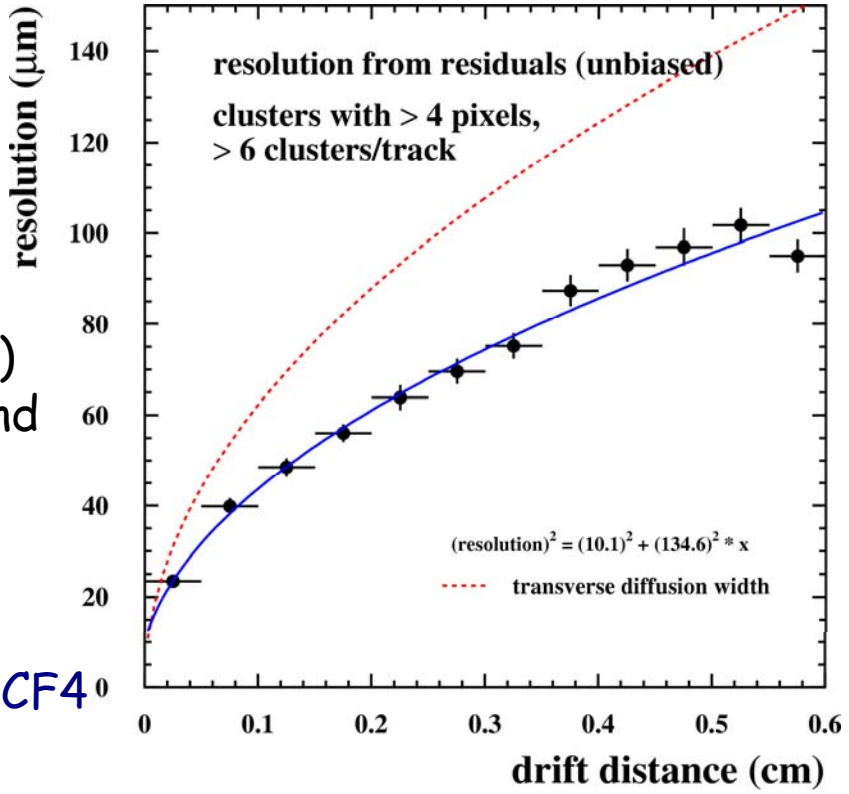
- Reconstructed cluster density very similar
  - Ar/CO2 (70/30): 6.3 cl./cm
  - He/CO2 (70/30): 6.2 cl./cm



5. Simulations for Testbeam

Single point resolutions:

- σ_0 quite similar to TB data
- resolution numbers for larger drift distances (still) somewhat larger
- no huge differences between ArCO2 and HeCo2 in resolution (~roughly in agreement with TB data)
- no huge difference between 1-2-2 and 1-1-1 setup (in agreement with TB data)



Ar/CH4/CO2 (93/5/2) and Ar/CO2/CF4 (90/5/5) mixtures have ~2x worse resolutions than Ar/CO2 or He/CO2

large diffusion in drift region and transfer region

large blobs

6. Summary and Plans

- Pixelized Readout of Micropattern Gas Detectors has been shown to be a quite attractive scheme to arrive at the BPLCTPC (=best possible linear collider TPC)

- Timepix appears to be operational! (=milestone)

- Good progress to understand the properties of this scheme
  - gas mixtures
  - integrated devices (INGrids)
  - simulation
  - first beamtest successful

- we are eagerly awaiting first Timepix samples for tests in detectors

- can start planning of a module for the EUDET infrastructure (in addition, small scale tests will of course continue)

7. Executive Summary