Επιταχυντές και Ανιχνευτές στην Πυρηνική και Σωματιδιακή Φυσική

Κ.Κορδάς Δ. Σαμψωνίδης

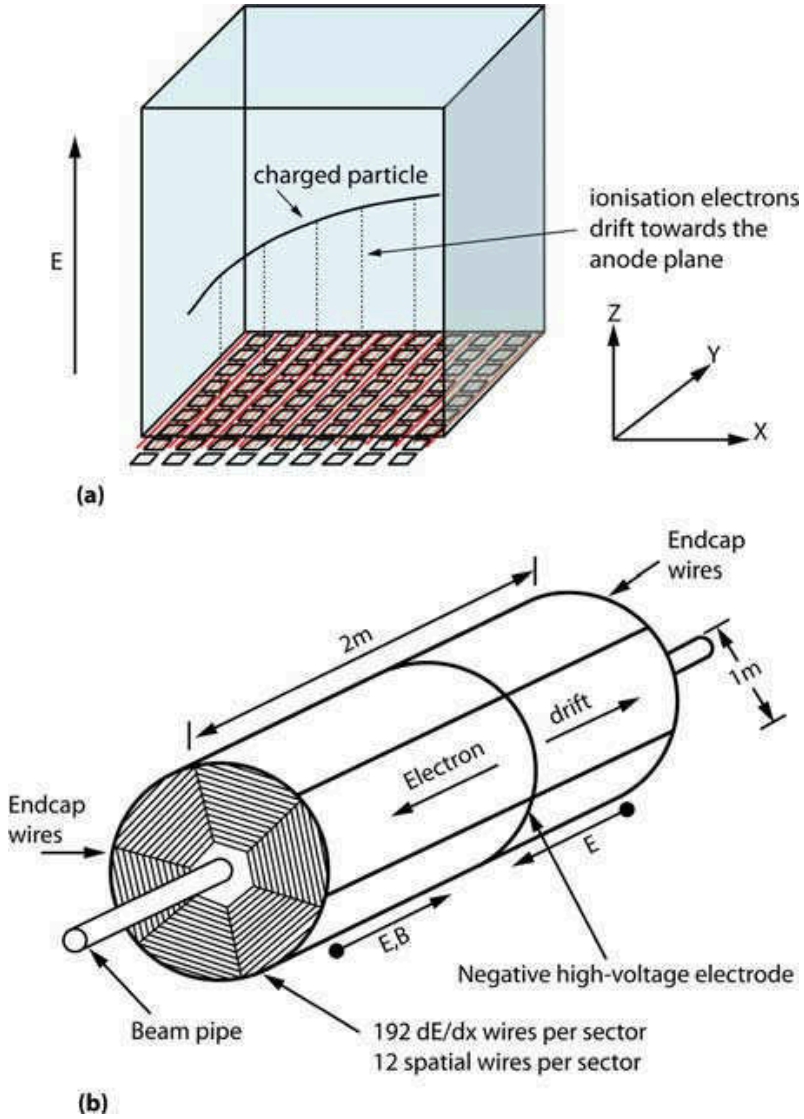
Διαλεξη 7η

Ανιχνευτές Αερίου

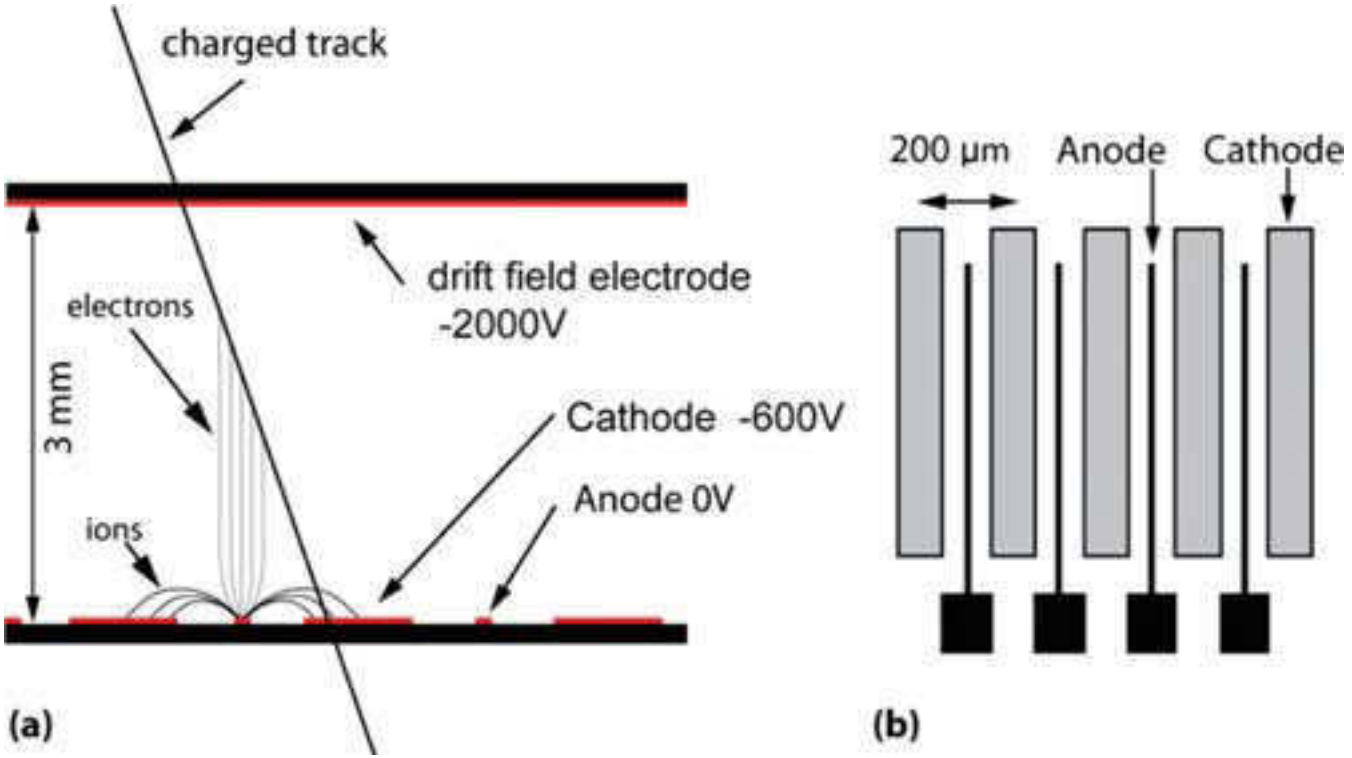
4. Time Projection chambers (TPC), micro-pattern gas detectors, κλπ

(στο επόμενο μάθημα που θα κάνουμε και όλες τις ασκήσεις της εργασίας #4 για τις οποίες ο Tavernier έχει λύσεις στο τέλος!)

TPC (Time Projection Chamber)



Micro-strip Gas Counters (MSGC)



Micro Pattern Gas Detectors

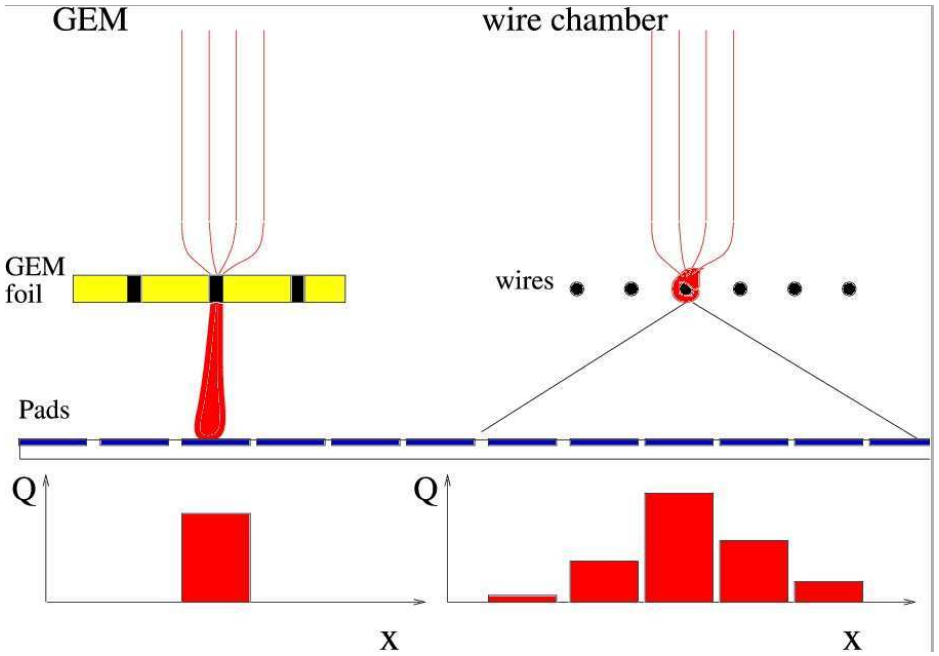
Detection of electron signal from MPGD:
no signal broadening by induction

⇒ short & narrow signals

If signal collected on one pad
⇒ No centre-of-gravity

Possible Solutions

- Smaller pads
- Replace pads by bump bonds of pixel readout chips
- Capacitive or resistive coupling of adjacent pads



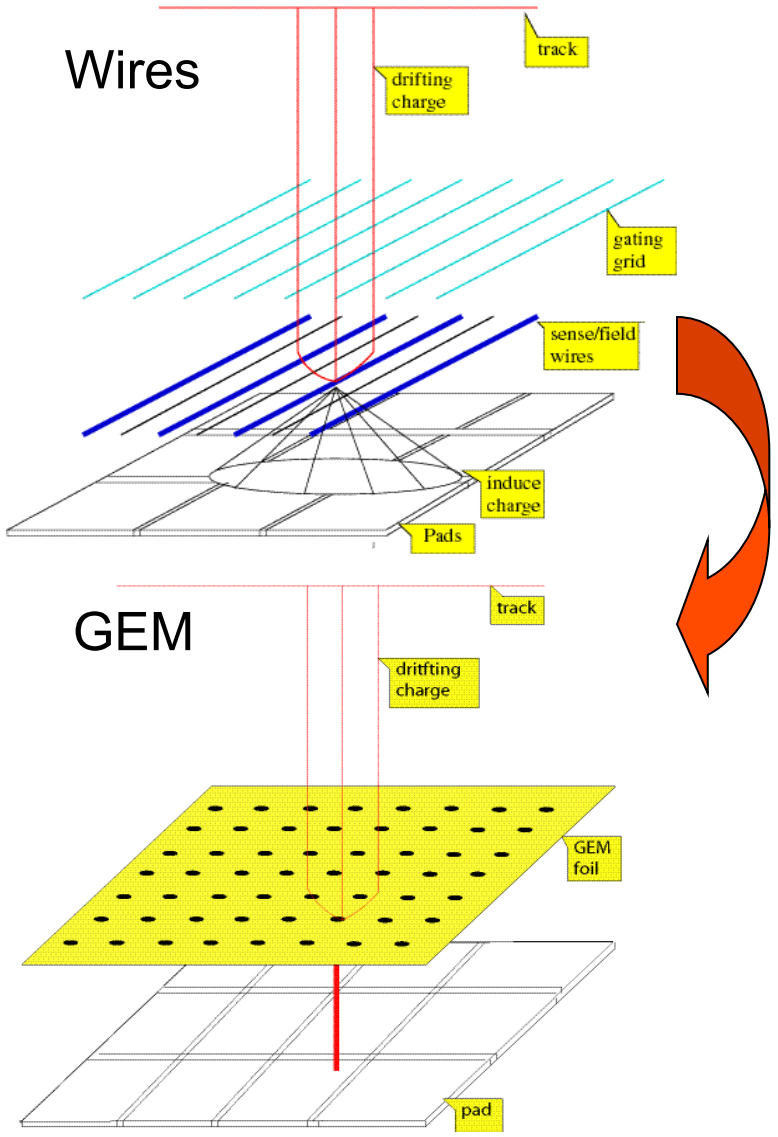
Time Projection Chamber

New concept for gas amplification at the end flanges:

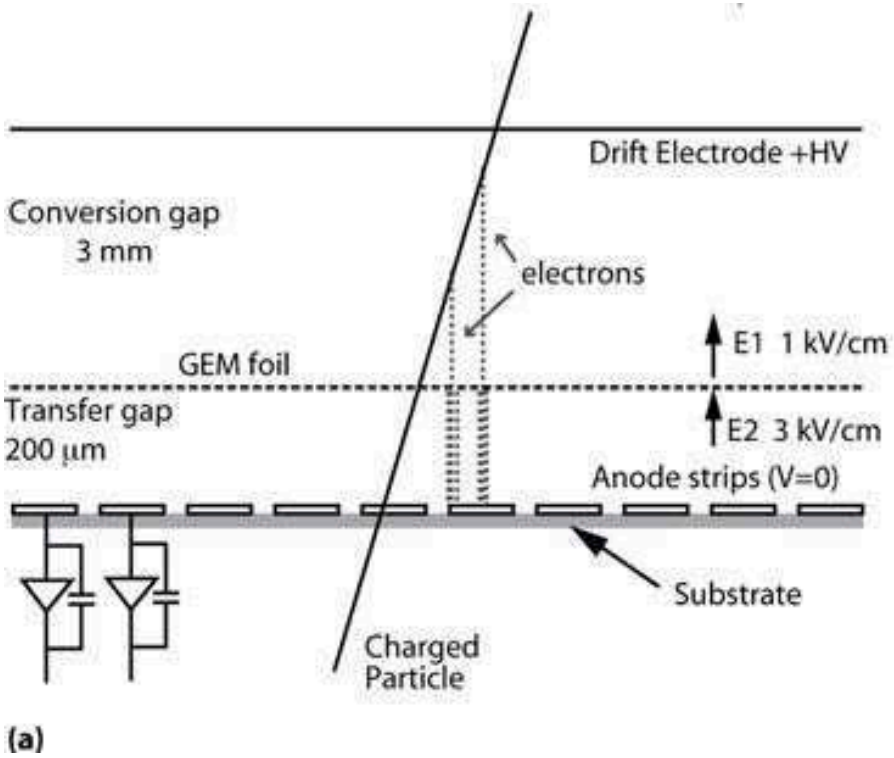
Replace proportional wires with Micro Pattern Gas Detectors

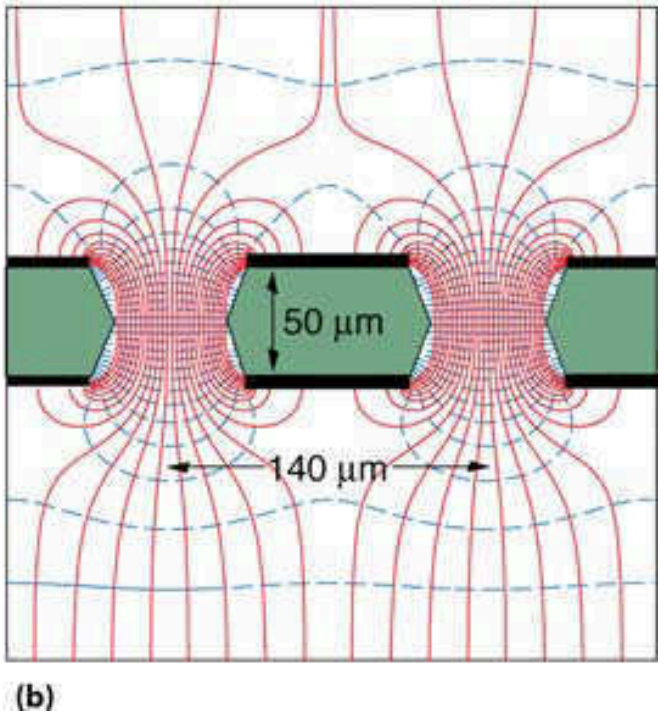
GEM or Micromegas

- Finer dimensions
- Two-dimensional symmetry
  (no E×B effects)
- Only fast electron signal
- Intrinsic ion feedback suppression



GEM

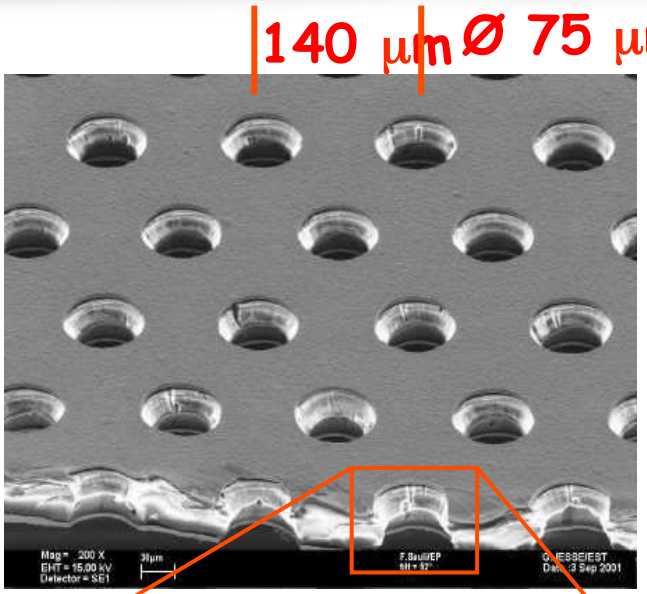

Drift Electrode +HV
Conversion gap
3 mm
electrons
E1 1 kV/cm
GEM foil
Transfer gap
200 μm
E2 3 kV/cm
Anode strips (V=0)
Substrate
Charged
Particle
(a)

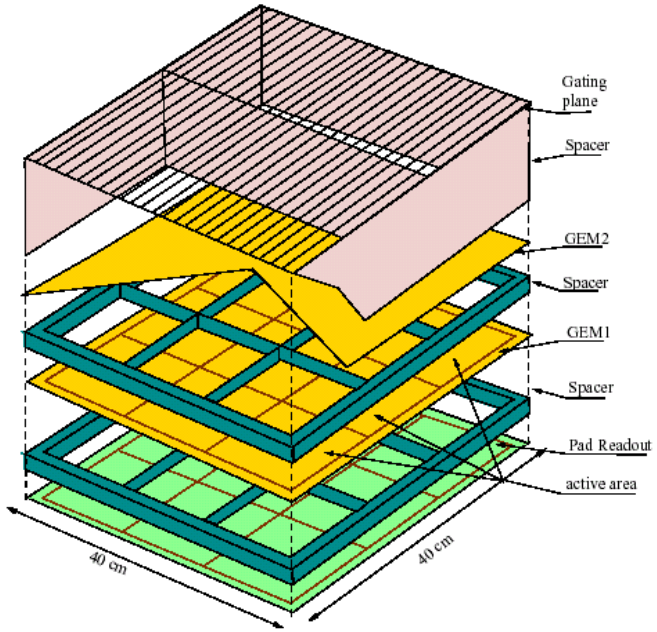

50 μm
140 μm
(b)

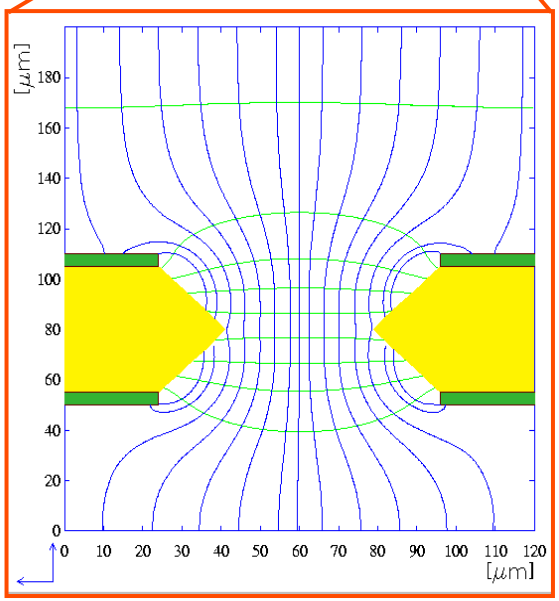
Gas Electron Multiplier (GEM) (F. Sauli 1996)

- 50 mm capton foil, double sided copper coated
- 75 mm holes, 140 mm pitch
- GEM voltages up to 500 V yield 10^4 gas amplification

For TPC use GEM towers for safe operation, e.g. COMPASS



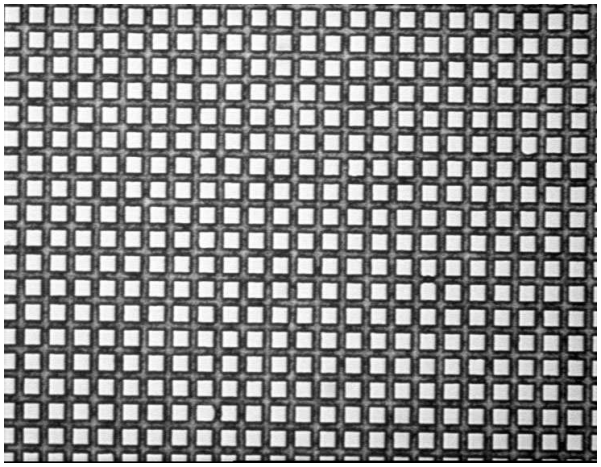


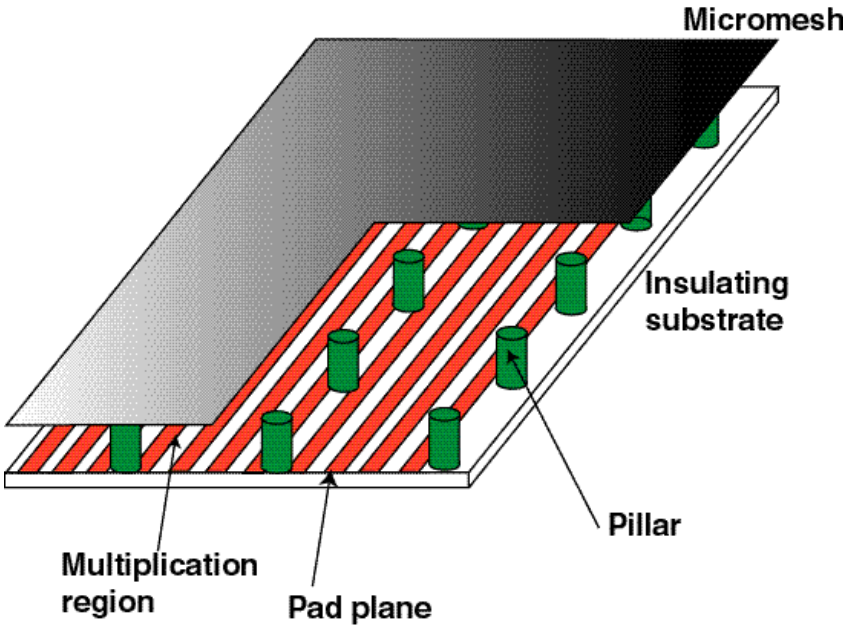


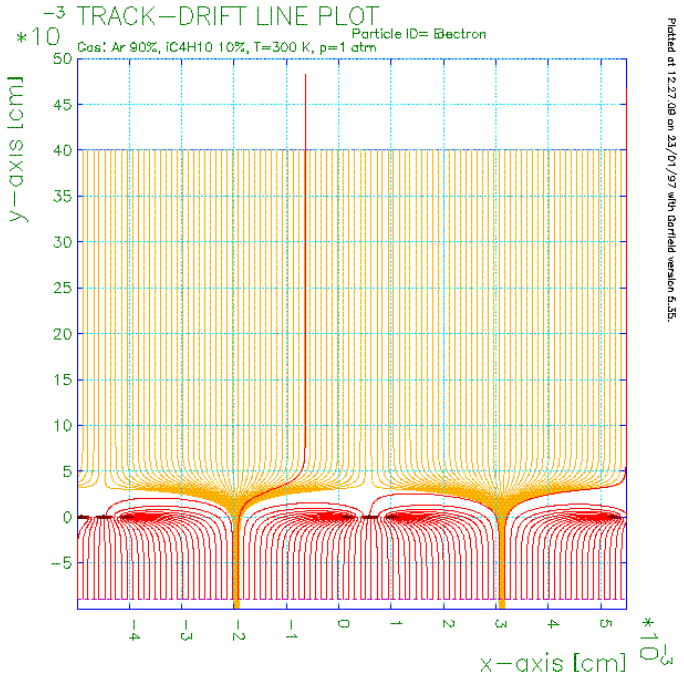
Micromegas (Y. Giomataris 1996)

- Asymmetric parallel plate chamber
- with micromesh
- Saturation of Townsend coefficient
- mild dependence of amplification
- on gap variations
- Ion feedback suppression

50 mm pitch







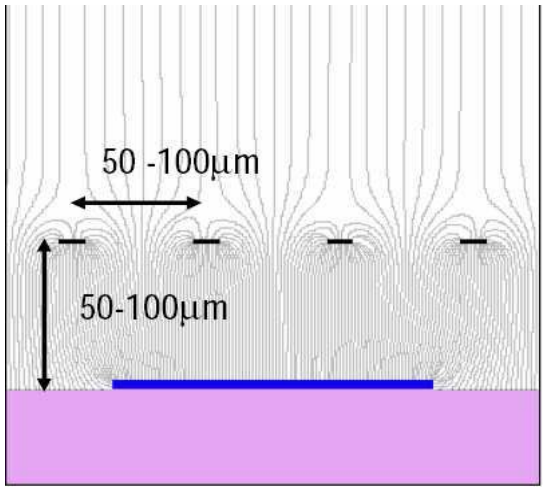
MICro MEsh GAseous Structure (MICROMEGAS)

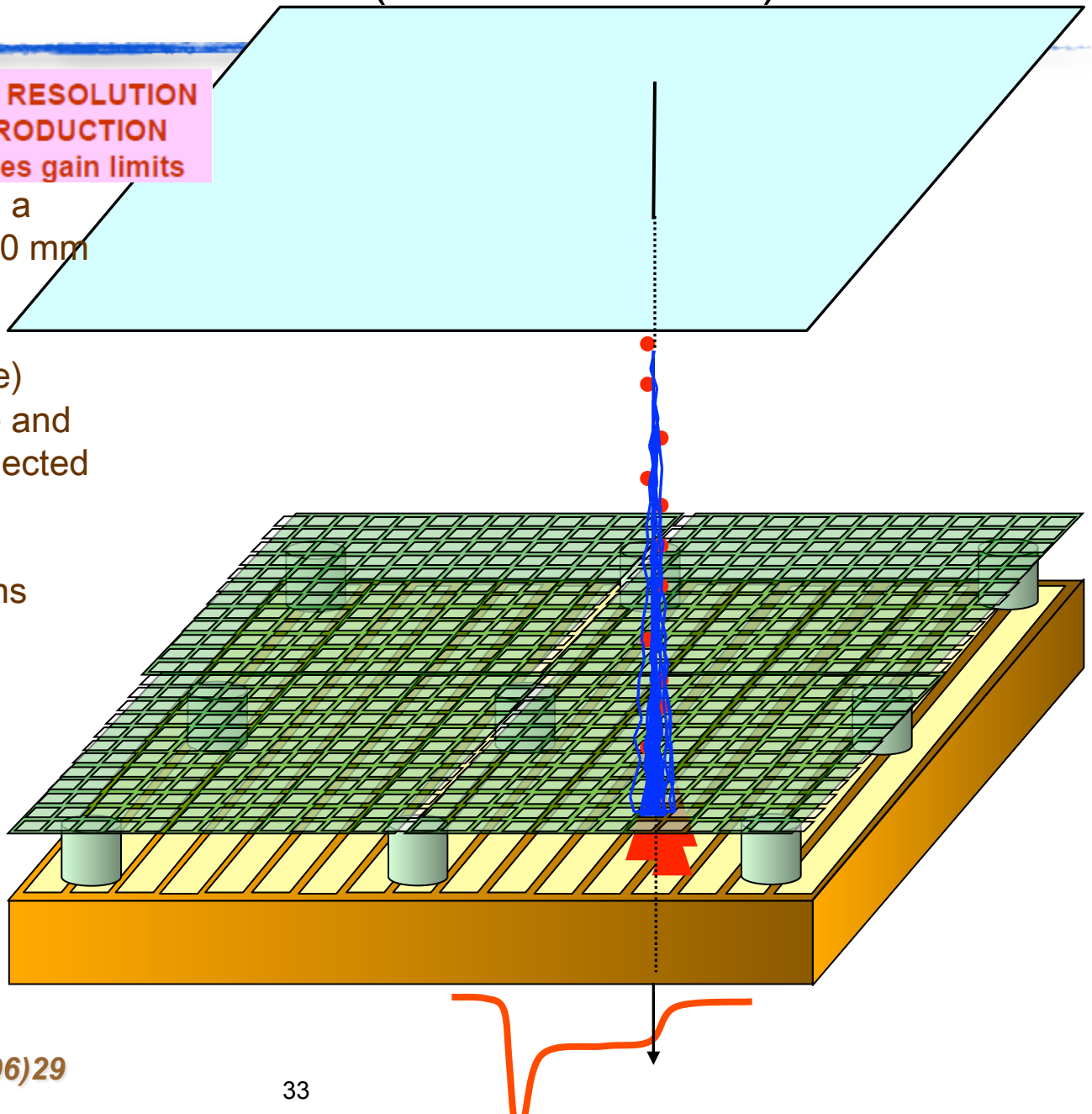
FAST, HIGH RATES, HIGH SPATIAL RESOLUTION
NEW TECHNIQUES FOR MASS PRODUCTION
BUT: only single-stage → sometimes gain limits

Micromesh Gaseous Chamber: a micromesh supported by 50-100 mm insulating pillars

Multiplication (up to 10^5 or more) takes place between the anode and the mesh and the charge is collected on the anode (one stage)

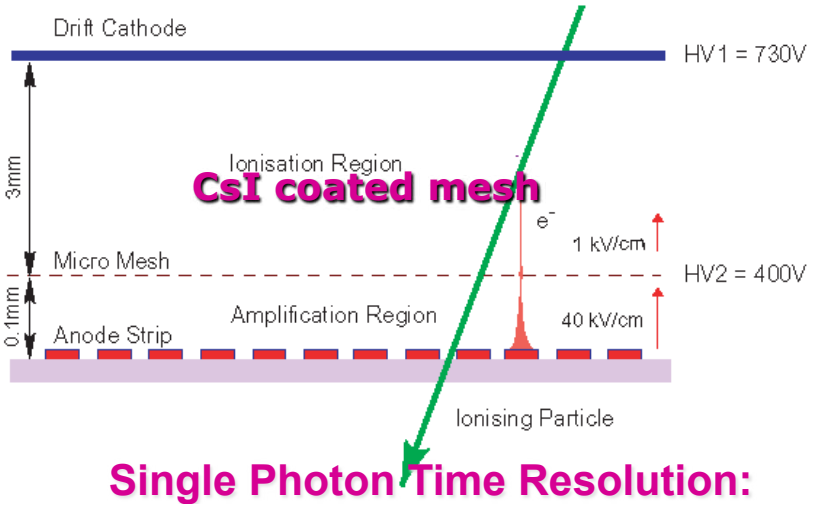
Small gap: fast collection of ions





Y. Giomataris et al, NIM A376(1996)29

MICROMEGAS time resolution (single photons)



Single Photon Time Resolution:

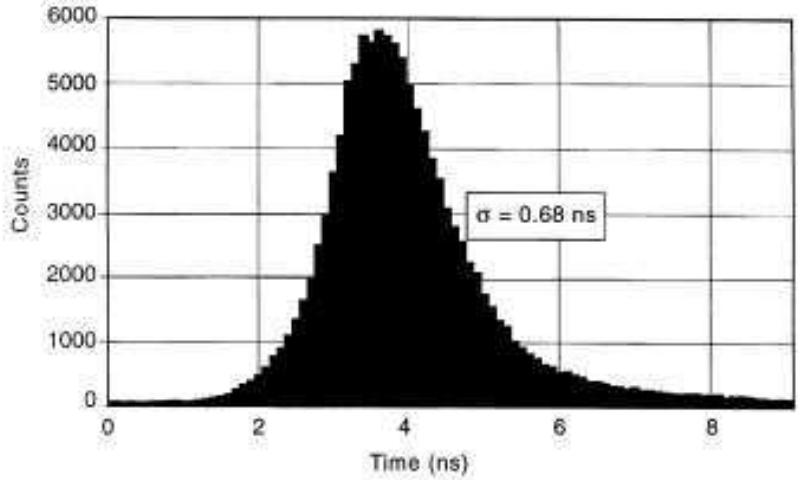
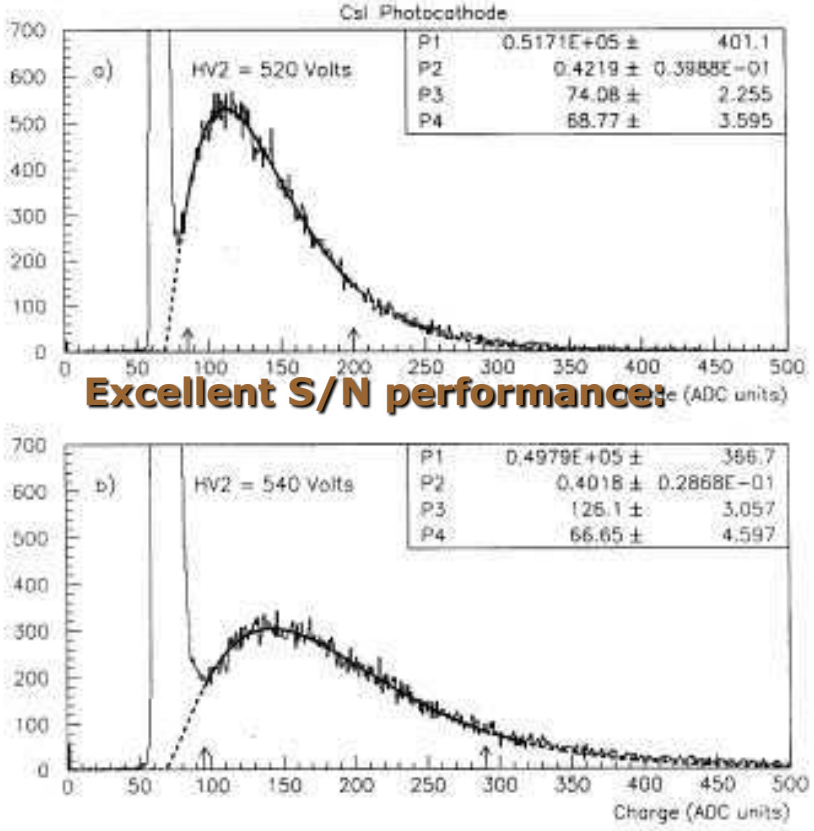


Fig. 11. Time distribution of the anode discriminated current signal of single photoelectrons for the CsI photoconverter.

Physical time jitters for UV photons → electron diffusion in the gas and noise.

Single photon pulse height distribution (Polya)



Excellent S/N performance:

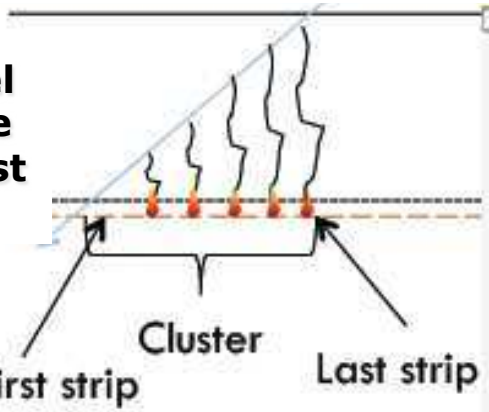
Fig. 10. Pulse height distribution of single photoelectron signal with the CsI photocathode for a mesh voltage of (a) 520 V, (b) 540 V in He + 6% isobutane. The solid line is the Polya fit (between arrows); the dashed line is its extrapolation.

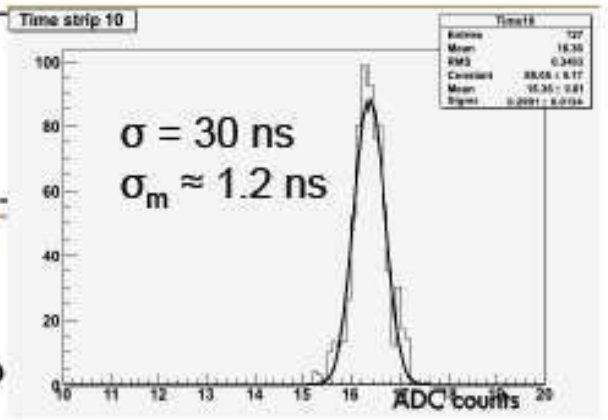
Micromegas Time Resolution : σ ~ 700 ps

J. Derre et al., NIM A449 (2000) 314

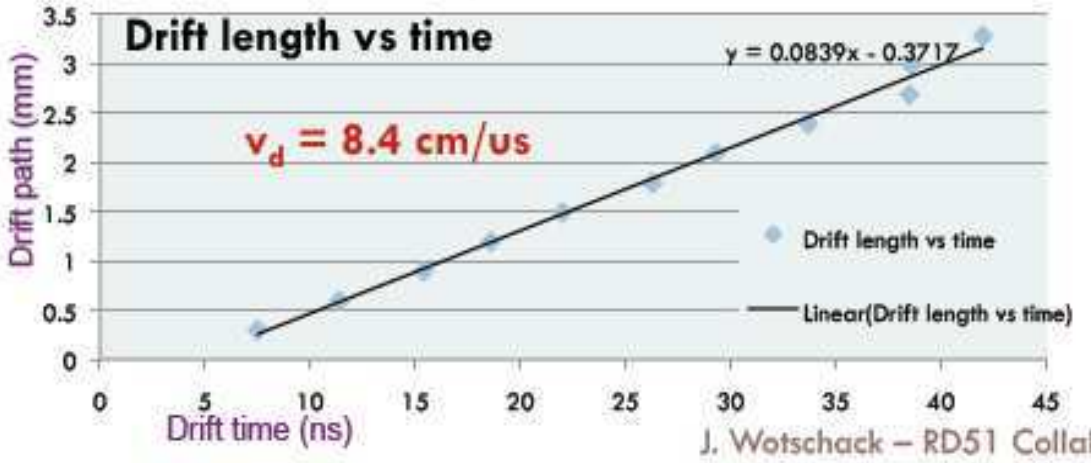
MICROMEGAS as TPC

The time information for each channel is extracted from the peak time of the ADC spectra. The strip with the earliest arrival time is taken as reference.

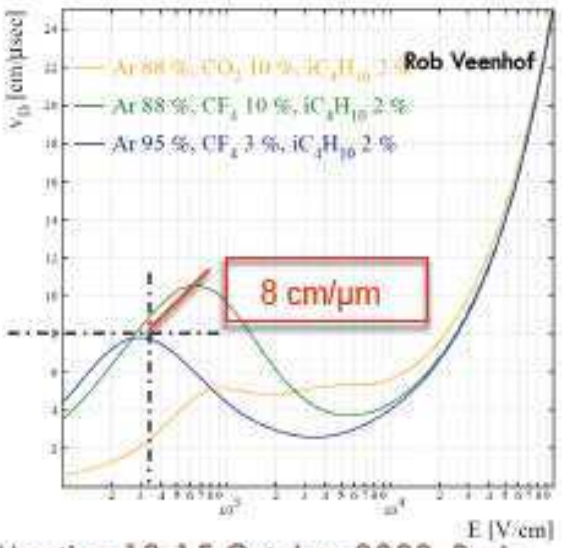




Even with non-optimal r/o electr. measuring the arrival time on each strip it is possible to measure the drift velocity or, with known drift velocity, the drift distance



Drift velocity

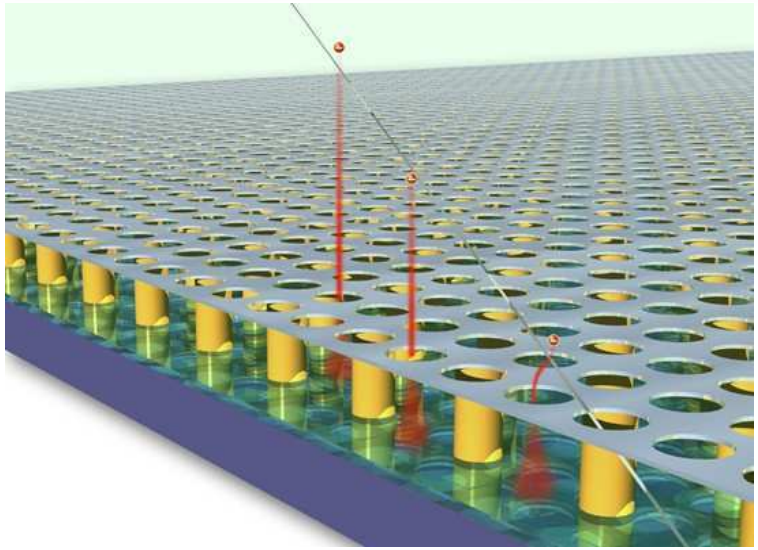


J. Wotschack – RD51 Collaboration Meeting 13-15 October 2008, Paris

A time resolution of ~1 ns results in space points with a resolution along the drift direction of ~50 μm

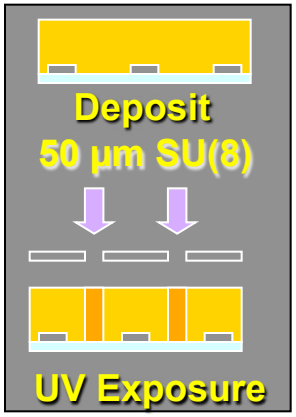
T. Alexopoulos et al, NIM A617 (2010) 161

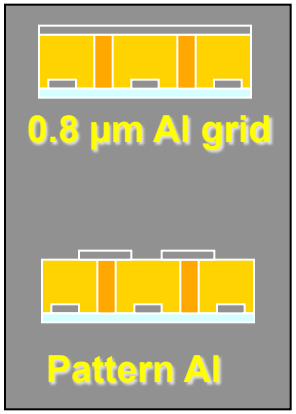
MICROMEGAS + Timepix CMOS Pixel Chip

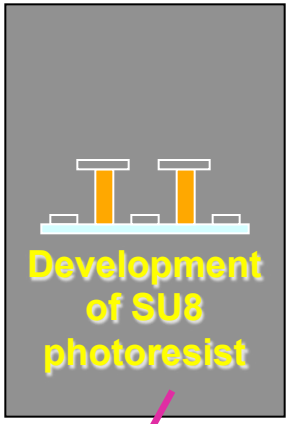


InGrid: integrate Micromegas & pixel chip by Si-wafer post-processing technology

- **Grid robustness & Gap/Hole accuracy**





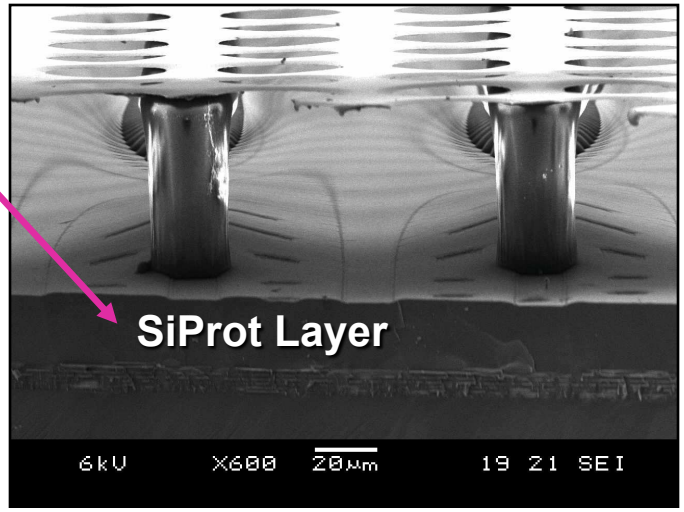


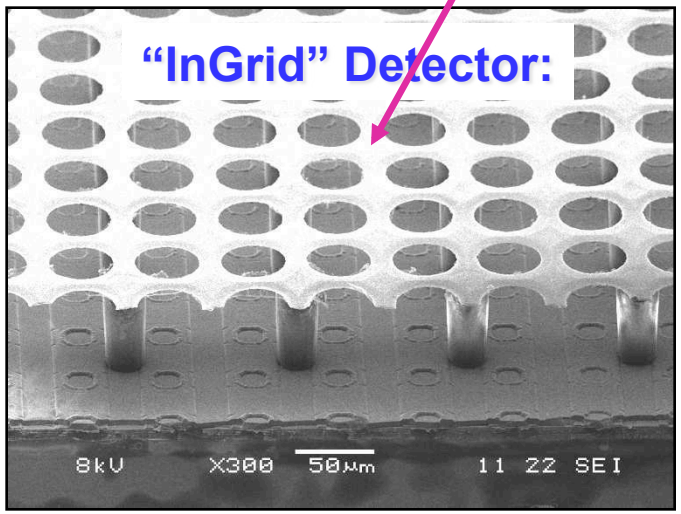
"Ingrid" + Silicon Protection Layer:

Apply Si3N4 (high resistivity layer 3-20 µm)

for discharge quench & SPARK PROTECTION

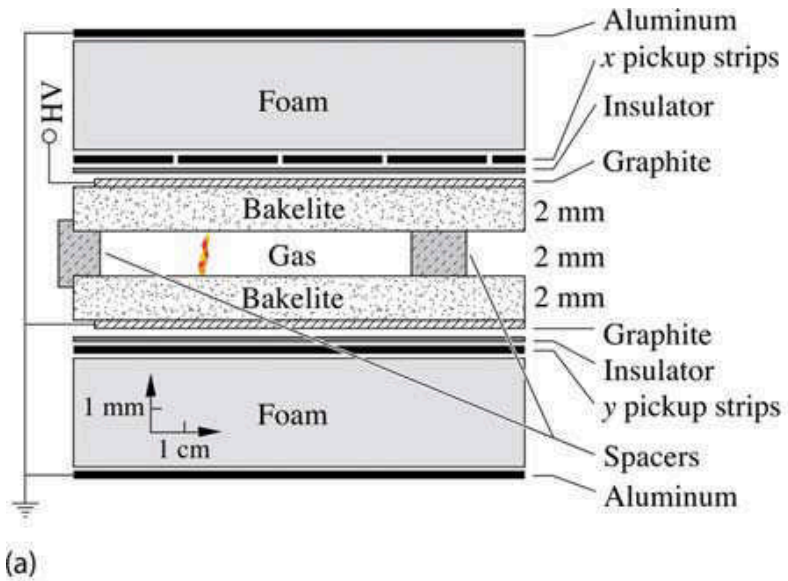
before InGrid production



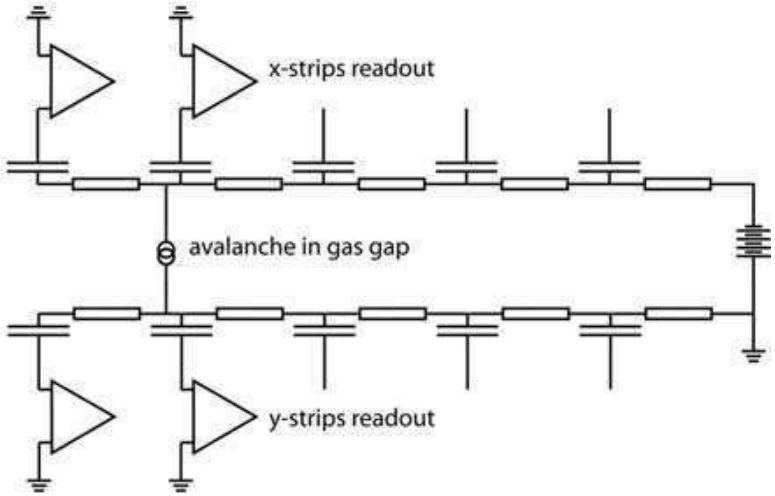


M. Chefdeville et al, NIMA556(2006) 490

Resistive Plate Chambers



(a)



(b)

HV: 7-12 KV

Signal : ~300mV (μεγάλο)

Πολύ καλή χρονική ακρίβεια

Μεγάλο νεκρό χρόνο
ΑΛΛΑ εντοπισμένο χωρικά στην περιοχή του σήματος
Ο υπόλοιπος θάλαμος ειναι ενεργός.