MICRO-PATTERN GAS DETECTORS

PART TWO: GASEOUS DETECTORS

Fabio SAULI TERA Foundation CERN CH-1211 GENEVA SWITZERLAND



MWPC

MULTIWIRE PROPORTIONAL CHAMBER Georges Charpak (1967)





G. Charpak et al, Nucl. Instr. and Meth. 62(1968)235

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PROTOTYPE FOR THE SPLIT FIELD MAGNET DETECTOR (1972):



MWPC CONSTRUCTION





THIN FRAMES ON HONEYCOMB PLATE:





20 µm wires at 2 mm pitch

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2-DIMENSIONAL MWPC READOUT

CENTER OF GRAVITY OF CATHODE INDUCED CHARGES

Two-dimensional coordinate readout:

$$X = \sum \frac{X_i A_i(X)}{A(X)} \qquad Y = \sum \frac{Y_i A_i(Y)}{A(Y)}$$

 X_i , Y_i : Coordinates of the strips $A_i(X)$, $A_i(Y)$: Charge on strips A(X), A(Y): Total charge



G. Charpak and F. Sauli, Nucl. Instr. and Methods 113(1973)381 E. Gatti et al, Nucl. Instr. and Meth. 163(1979)83

MEDICAL IMAGING

BETA RADIOCHROMATOGRAPHY: ANATOMICAL SAMPLES LABELLED WITH A BETA-EMITTER MOLECULE

E. Tribollet et al, Proc. Natl. Acad.Sci.USA 88(1991)1466



REGIONAL UPTAKE OF DEOXYGLUCOSE IN A DOG'S HEART

M. G. Trivelli et al, Cardiovascular Res. 26(1992)330



MWPC WITH A FIELD-SHAPING WIRE BETWEEN ANODES, TO AVOID LOW-FIELD REGIONS



SPACE-TIME CORRELATION (**RIGHT-LEFT AMBIGUITY**):



A. H. Walenta, J. Heintze and B. Scürlein, Nucl. Instr. and Meth. 92(1971)373

HIGH ACCURACY DRIFT CHAMBERS





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JET CHAMBER (DESY)



H. Drumm et al, Nucl. Instr. and Meth. 176(1980)333

IMAGING CHAMBER

TIME PROJECTION CHAMBER (TPC)

D. Nygren (1975)



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3-D RECONSTRUCTION OF TRACKS



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WORLD LARGEST TPC

ALICE AT LHC

Inner/Outer radius: 845/2466 mm Drift length: 2x2500 mm 557568 readout pads



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VERY LARGE TRACK MULTIPLICITY

ALTRO:PROGRAMMABLE DIGITAL FILTER

- ion tail cancellation
- baseline restoration
- common mode subtraction





B. Mota et al, Nucl. Instr. and Meth. A535(2004)500

X-Y PROJECTION: WIDE INDUCED CHARGE PROFILE



DRIFT TIME RESOLUTION: POSITIVE ION TAIL CANCELLATION AND OVERSHOOT



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R. Kotthaus, Nucl. Instr. and Meth. A252(1986) 531



EXAMPLES OF ORGANIC POLYMERS AND SILICON COMPOUNDS DEPOSITS IN MWPC



M. Binkley et al, Nucl. Instr. and Meth.A515(2003)53

J. Kadyk, Nucl. Instr. and Meth. A300(1991)436



MAXIMUM GAIN: PRODUCT OF CATHODE AND ANODE AVALANCHE MULTIPLICATION

P. Giubellino et al, Nucl. Instr. and Meth. A245(1986)155

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MICROSTRIP GAS CHAMBERS (MSGC) A. Oed (1988)



THIN METAL STRIPS ETCHED ON GLASS



A.Oed, Nucl. Instr. and Meth. A263(1988)351

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TWO-TRACK RESOLUTION



A. Barr et al, Nucl. Instr. and Meth. A392(1997)99

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DISCHARGE DAMAGES



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MSGS AGING: EXTREME SENSITIVITY TO POLLUTANTS



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MICRO-GAP CHAMBER



R. Bellazzini et al, Nucl. Instr. and Meth. A335(1993)69

FIELD GRADIENT LATTICE DETECTOR (FGLD)

L.Dick et al Nucl. Instr. and Meth. A535(2004)347

MICRO-GROOVE CHAMBER



R. Bellazzini et al, Nucl. Instr. and Meth. A424(1999)444

MICRO-PIXEL CHAMBER



MICRO MEsh GAseous Structure

THIN GAP PARALLEL PLATE AVALANCHE CHAMBER





Y. Giomataris et al, Nucl. Instr. and Meth. A376(1996)29



GAS ELECTRON MULTIPLIER

Holes pattern on Cu-plated polymer 50 µm thich







F. Sauli, Nucl. Instrum. Methods A386(1997)531

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MICROMEGAS

FAST ELECTRON SIGNALS WITH SLOW ION TAIL:





Ar+10% Isobutane



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MICROMEGAS: VERY GOOD ENERGY RESOLUTION



A. Delbart et al, Nucl. Instr. and Meth. A461(2001)84

TIME RESOLUTION: (FOR ISOCHRONOUS ELECTRONS)



J. Derré et al, Nucl. Instr. And Meth. A449(2000)314



GEM SIGNAL CHARGE DISTRIBUTION:

Fabio Sauli - Seminario Nazionale Rivelatori Innovativi (Frascati, 30.11-4.12.2009)

SPACE AND TIME RESOLUTION IN EXPERIMENT CONDITIONS



COMPASS MICROMEGAS:

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0

2.5

5

7.5

10

M. Alfonsi et al, Nucl. Instr. and Meth. A518(2004)106

12.5

Integrated Charge (C/cm²)

15

17.5

20





MICROMEGAS RATE CAPABILITY:



G. Charpak et al, Nucl. Instr. And Meth. 478(2002)26

MICROMEGAS RADIATION HARDNESS:



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GAIN AND DISCHARGE RATE ON EXPOSURE TO HEAVILY IONIZING PARTICLES



C. Büttner et al, Nucl. Instr. and Meth. A409(1998)79 S. Bachmann et al, Nucl. Instr. and Meth. A479 (2002) 294



Fabio Sauli - Seminario Nazionale Rivelatori Innovativi (Frascati, 30.11-4.12.2009)

DISCHARGE RATES IN HADRON BEAM

COMPASS TRIPLE-GEM:

PSI π M1 beam No discharges in 12 hrs of operation at gain 10⁴



S. Bachmann et al, Nucl. Instr. and Meth. A470(2001)548





D. Neyret, MPGD2009 (Crete, June 12-17, 2009)

Fabio Sauli - Seminario Nazionale Rivelatori Innovativi (Frascati, 30.11-4.12.2009)

GEM GAIN UNIFORMITY

GAIN DEPENDENCE FROM HOLE DIAMETER



J. Benlloch et al, Nucl. Instr. And Meth. A419(1998)410

Fabio Sauli - Seminario Nazionale Rivelatori Innovativi (Frascati, 30.11-4.12.2009)



GEMS PRODUCED BY TECHETCH:

F. Simon, IEEE Nucl. Sci. Symp. Conf. Records (San Diego Oct 2006)

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CORRELATION HOLE DIAMETER-GAIN INCREASE:



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SURFACE CHARGE MODIFY THE FIELD:

BEFORE









0.5

0

20

40

60

80

100

120

Time (hrs)

140

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RATE DEPENDENCE OF CHARGING UP

PRESSURE AND TEMPERATURE DEPENDENCE OF GAIN

GEM



C. Altumbas et al, Nucl. Instr. and Meth. A515(2003)249

MICROMEGAS



M. Chefdeville, MPGD2009 (Crete 12-15 June 2009)

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W. Blum, W.Riegler and L. Rolandi, Particle Detection with Drift Chambers (Springer 2008)

ION FEEDBACK IN MICROMEGAS

The fractional ion feedback depends on avalanche spread, but cannot be smaller than the field ratio:



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ION FEEDBACK

ION FEEDBACK IN MULTIGEMS

The fractional ion feedback in multi-GEM detectors results from a complex interplay of geometry, fields, diffusion:







M. Killenberg et al, Nucl. Instr. and Meth. A530(2004)251

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SPACE CHARGE DISTORTIONS

PANDA GEM TPC (SIMULATION)



X. Zhang, MPGD09







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DOUBLE MICROMEGAS



F. Jeanneau et al, TIPP09 (Tsukuba 2009)

Fabio Sauli - Seminario Nazionale Rivelatori Innovativi (Frascati, 30.11-4.12.2009)