MICRO-PATTERN GAS DETECTORS

PART 3: APPLICATIONS AND NEW DEVELOPMENTS

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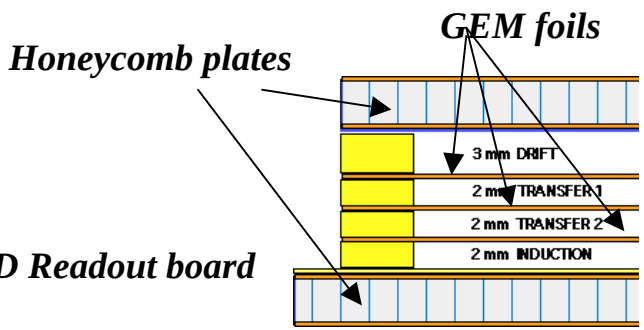
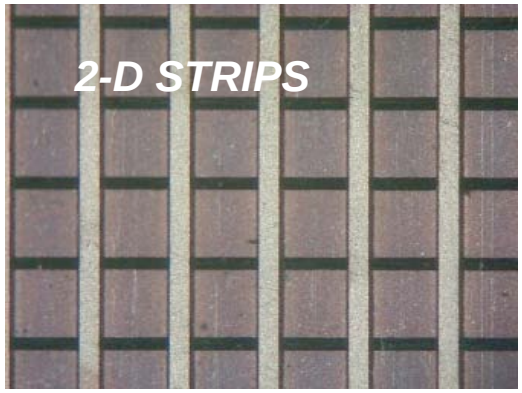
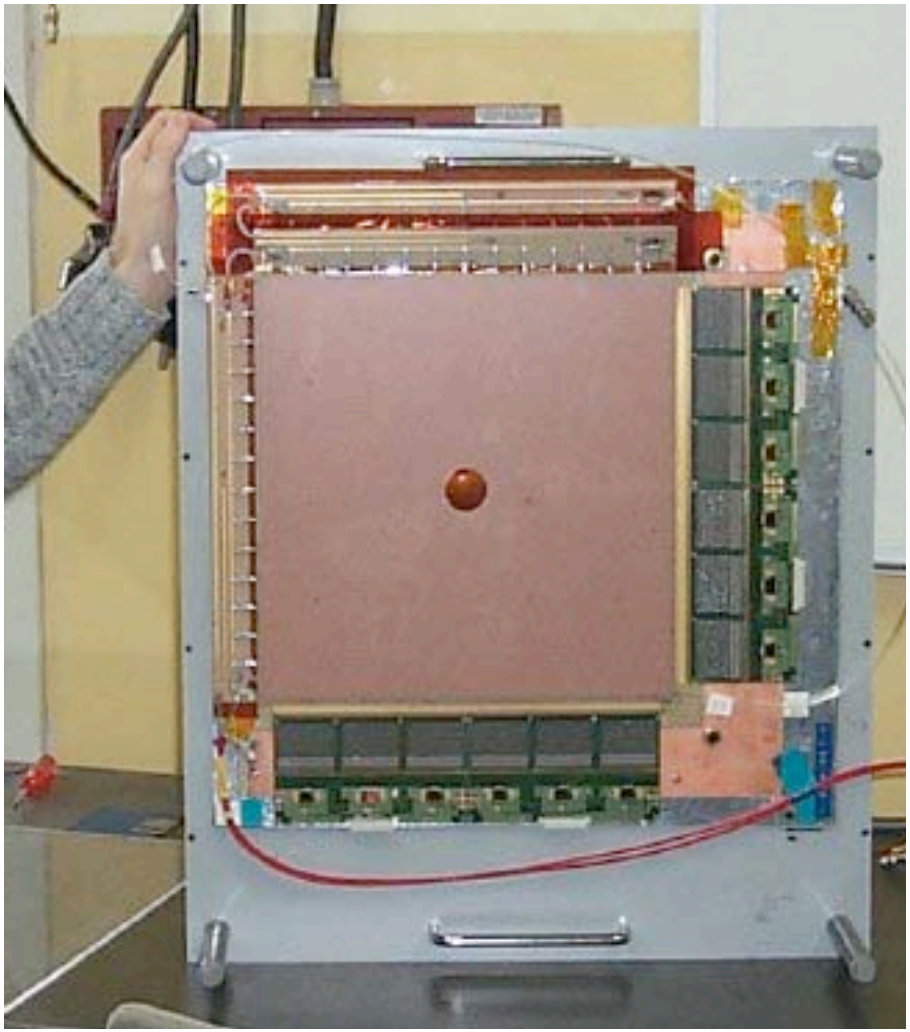
LIGHT MULTIGEM CONSTRUCTION

31x31 cm^2 active
2-D strip readout
Total thickness in active area ~ 0.7% X_0



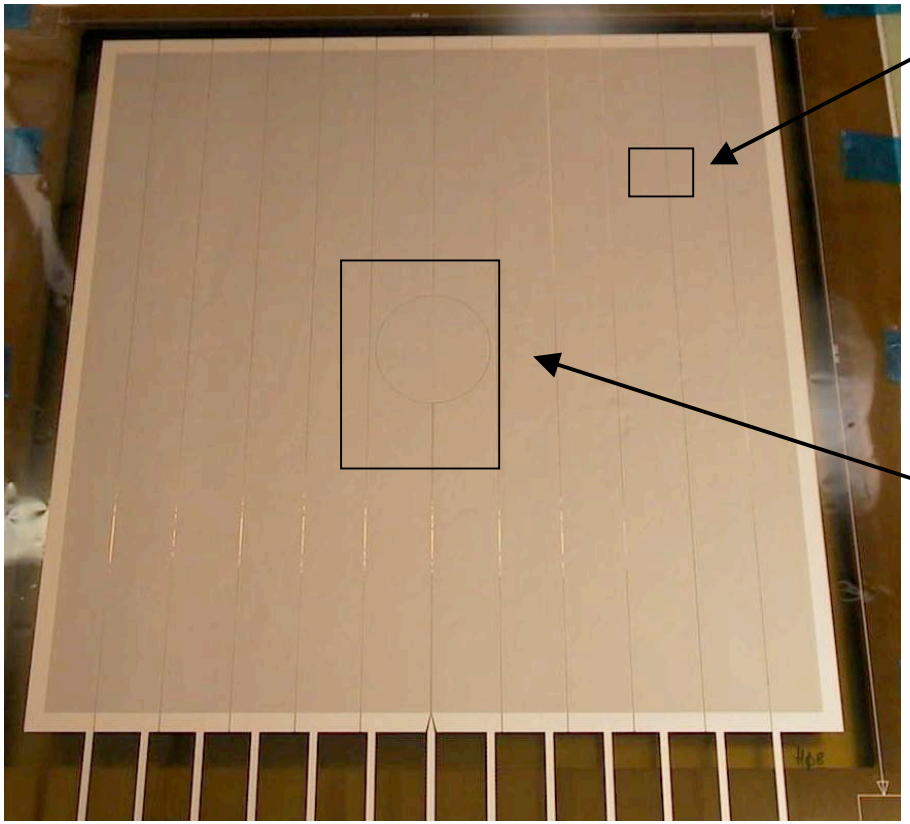
Pitch: 400 µm
Top strips: 80 µm
Bottom strips: 350 µm

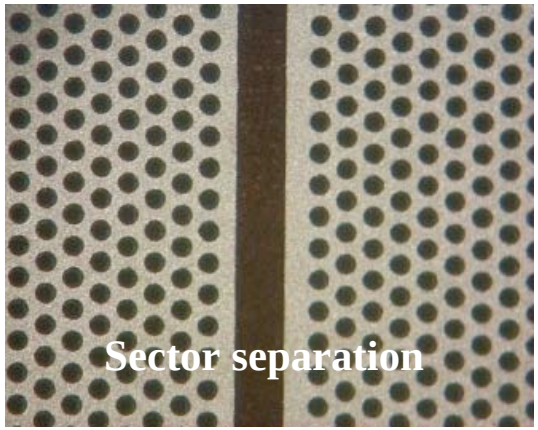


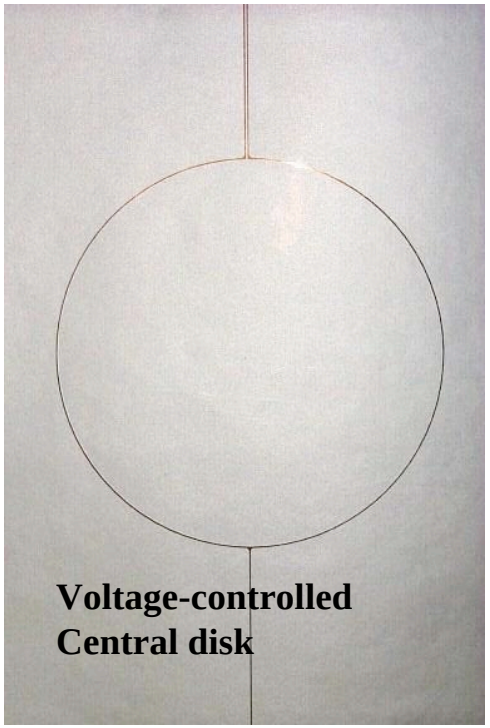


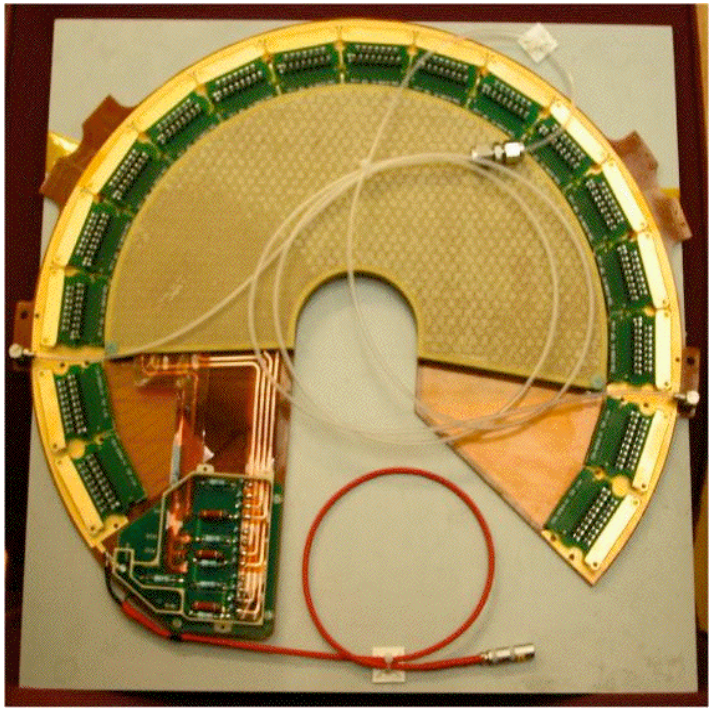
C. Altumbas et al, Nucl. Instrum. Methods A490(2002)177
B. Ketzer et al, Nucl. Instr. and Meth. A535(2004)314

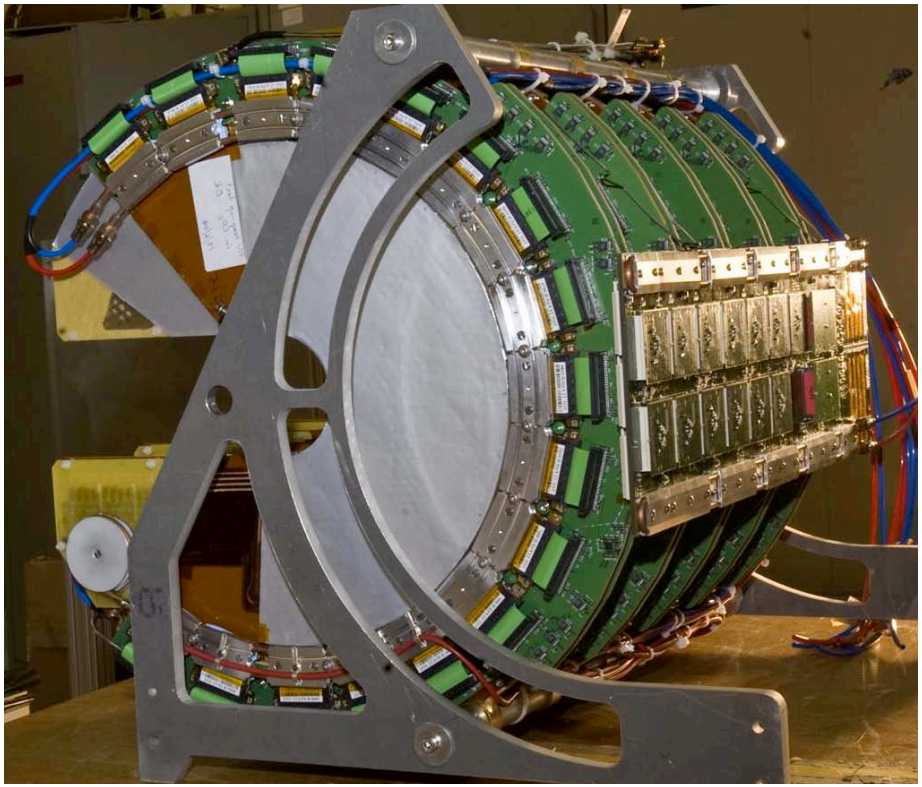
SECTORING:
12 Sectors with individual protection resistor
Voltage-controlled central Beam Killer



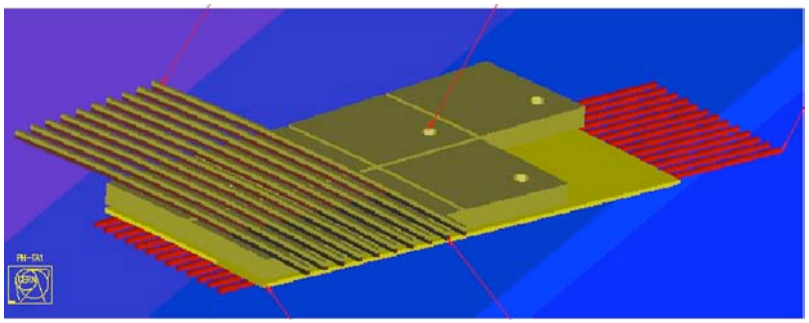






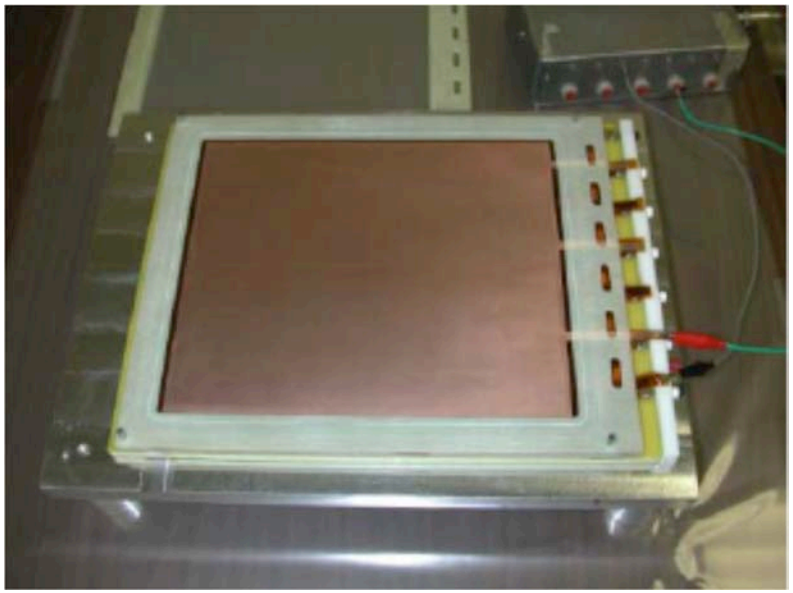


STRIPS AND PADS READOUT

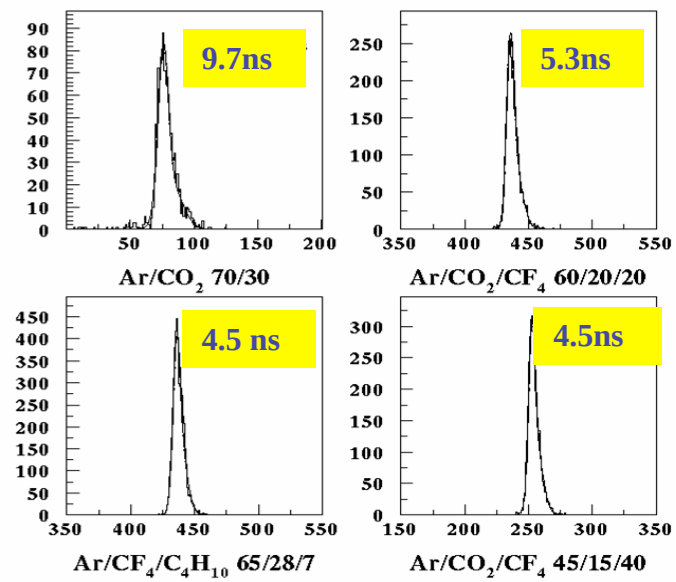


M.G. Bagliesi et al,
Nucl. Instr. And Meth. In press (2009)

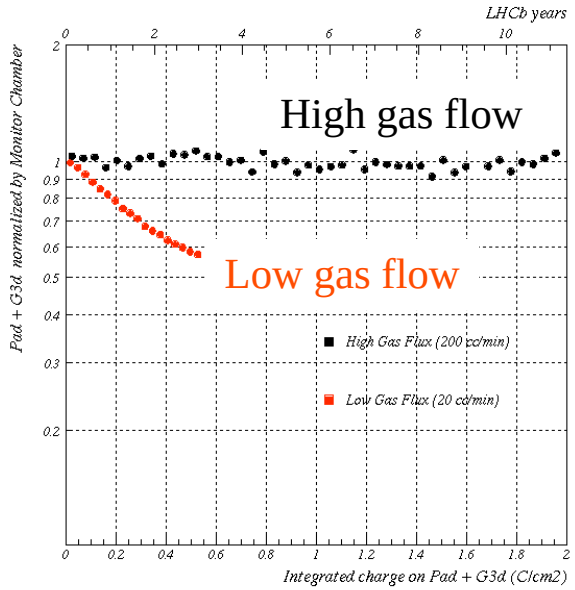
TRIPLE GEM WITH FAST GAS MIXTURES



TIME RESOLUTION:



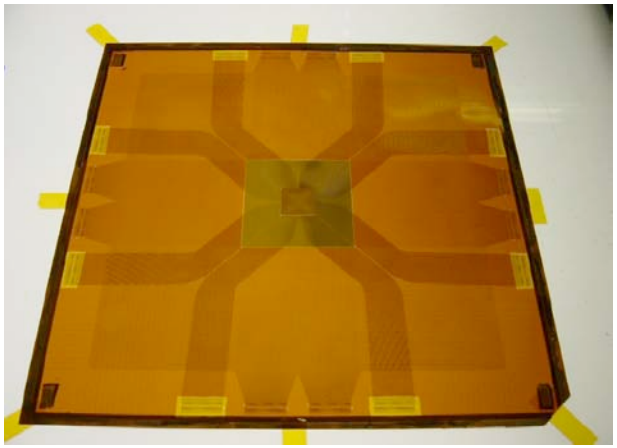
AGING:



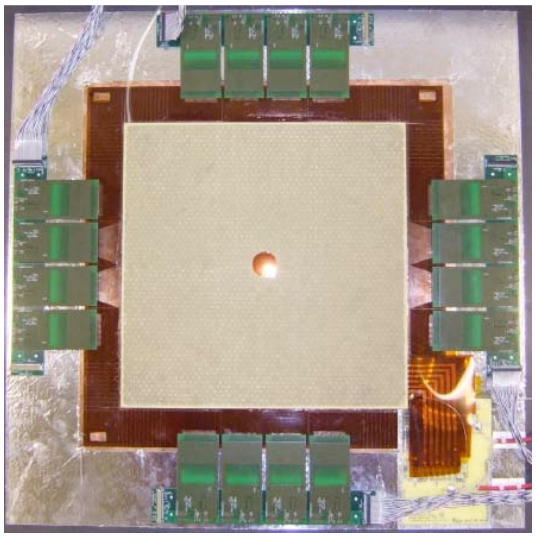
G. Bencivenni et al, Nucl. Instr. And Meth. A494(2002)156
M. Alfonsi et al, Nucl. Instr. And Meth. A518(2004)106

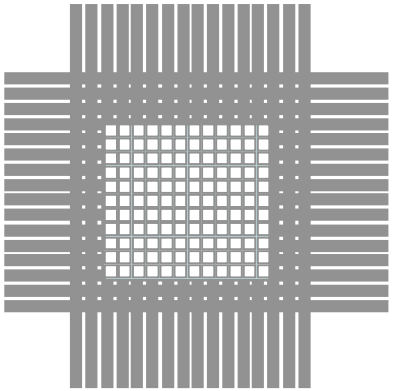
TRIPLE GEM WITH PIXEL AND STRIPS READOUT

Center: 32x32 PIXELS, 1 mm^2 each
Sides: 512x512 STRIPS, 400 μm pitch

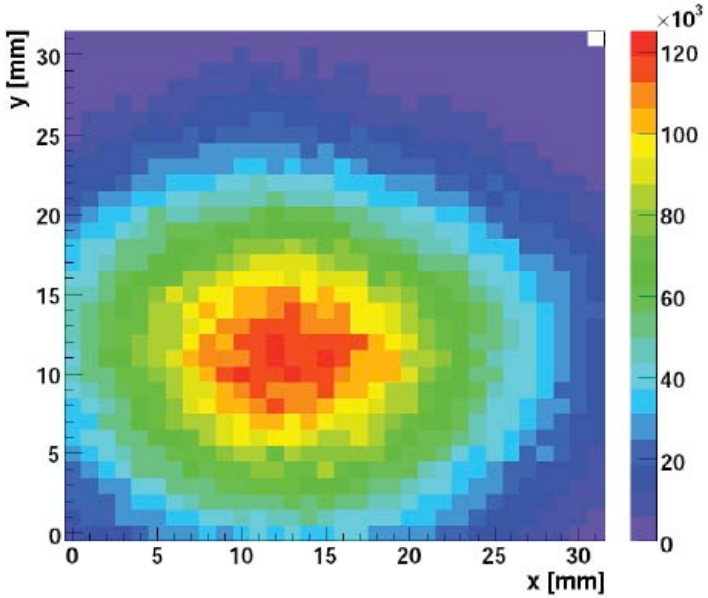


F. Haas et al, Vienna Instr. Conf (Feb. 2007)



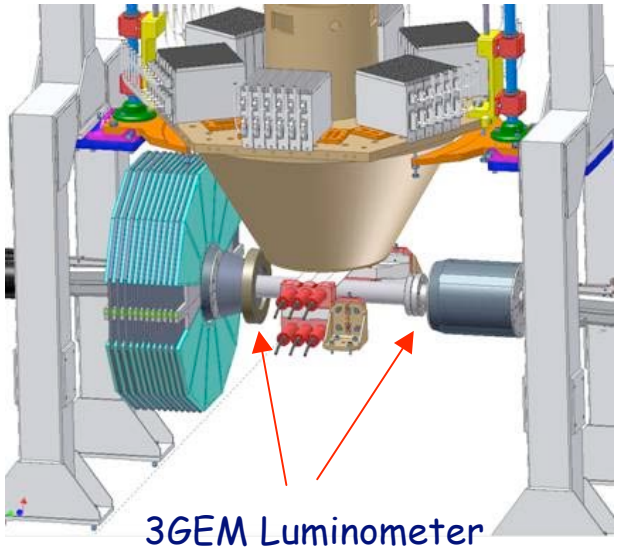


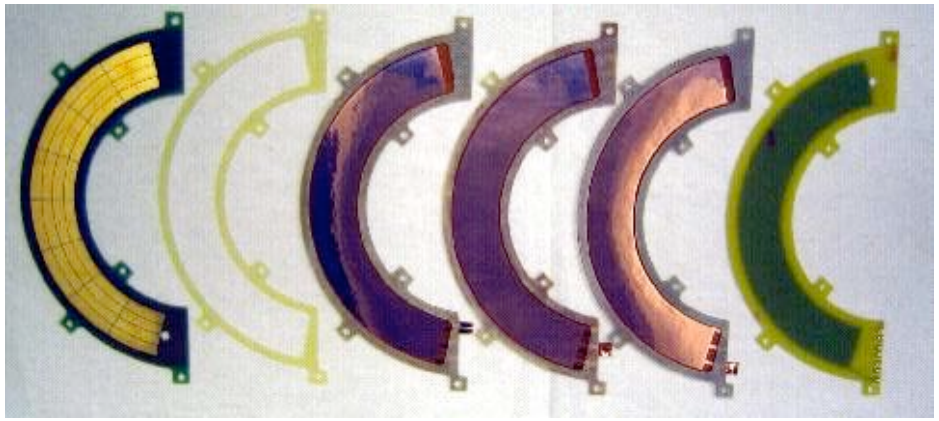
HIGH FLUX BEAM:



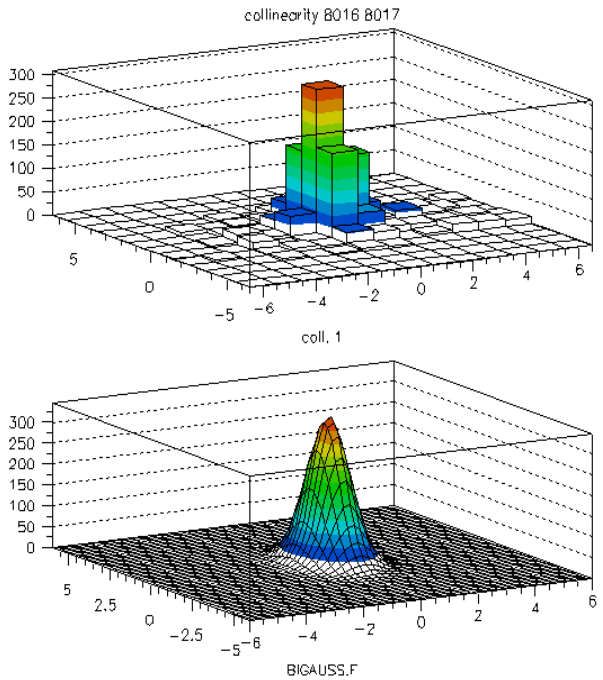
B. Ketzer et al, IEEE Nucl. Sci. Symp. Conf. Rec. (Dresden, 19-25 Oct. 2008)

BHABHA TRACKER FOR DAPHNE UPGRADE LNF



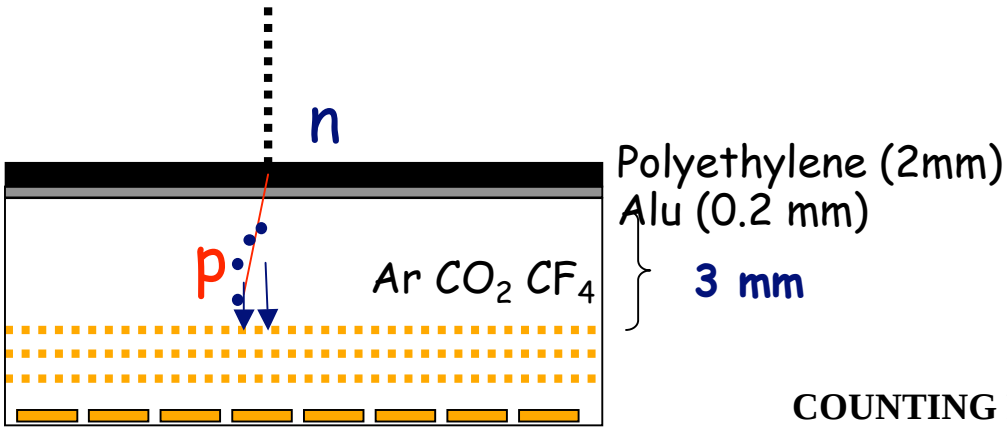


BHABHA CORRELATION:



F. Murtas, RD51 Coll. Meeting (Paris Oct. 13-15, 2008)

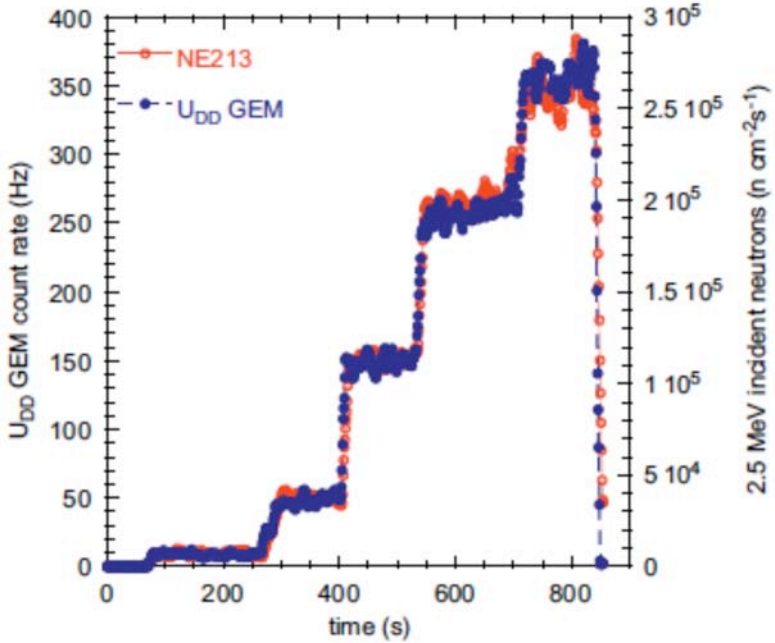
TRIPLE GEM WITH CONVERTERS



14 MeV

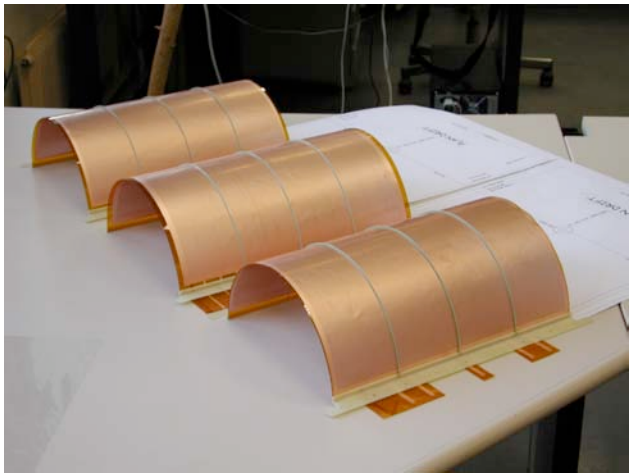
2.5 MeV

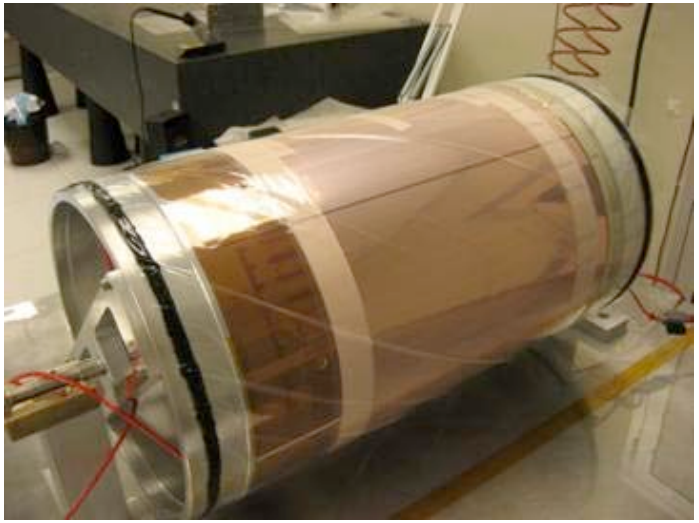
COUNTING RATE LINEARITY

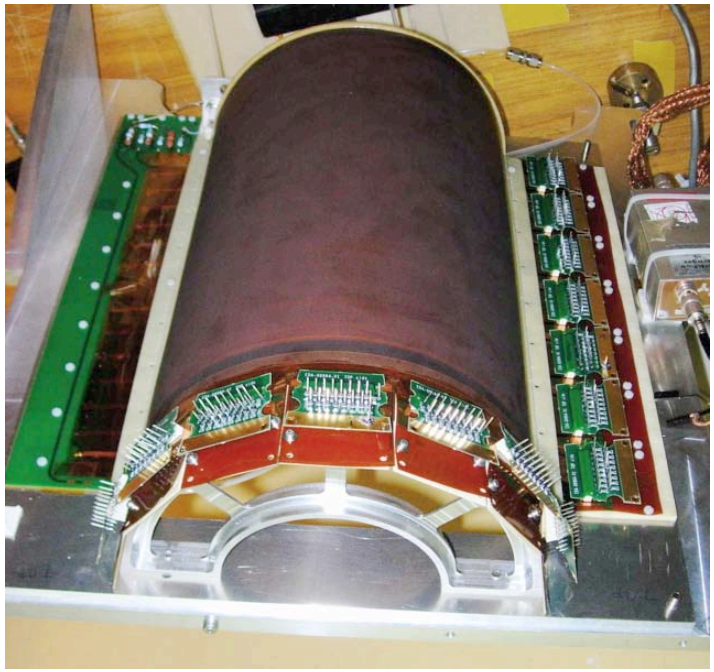


F. Murtas, RD51 Coll. Meeting (Paris Oct. 13-15, 2008)

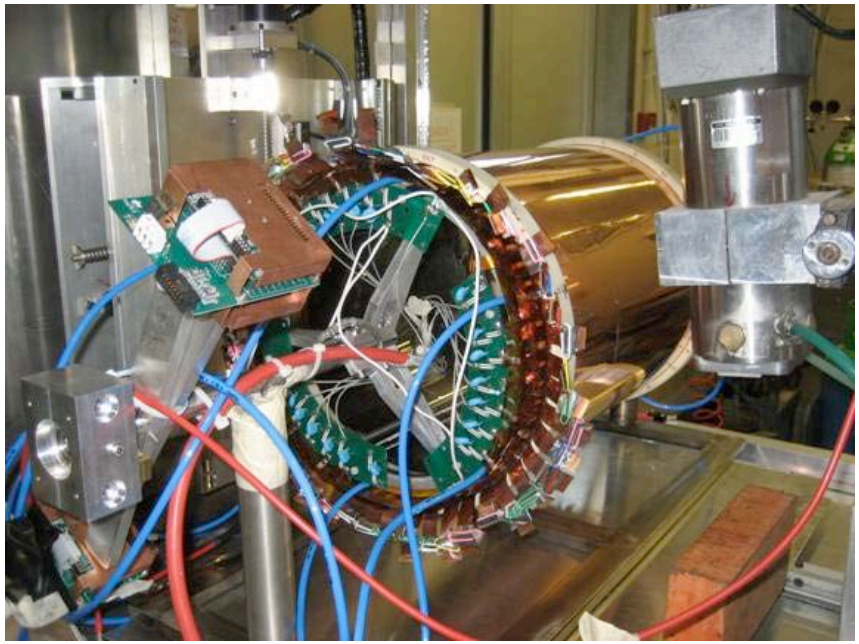
B. Esposito et al, Nucl. Instr. And Meth. In press (2009)







L. Ropelewski, Vienna Instr. Conf. 2007



G. Bencivenni, RD51 Workshop (Paris Oct. 2008)

DOUBLE MASK PROCESS

50 µm Kapton +5 µm Cu

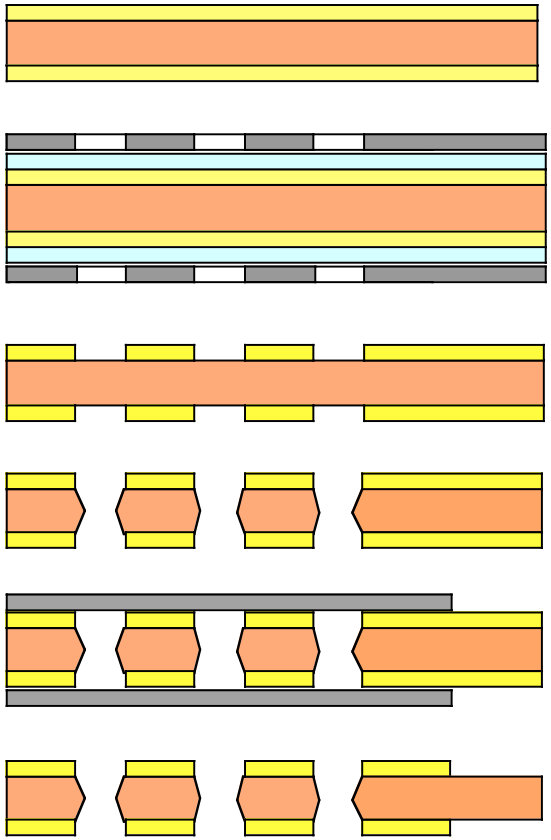
Photoresist coating, masking and exposure to UV light

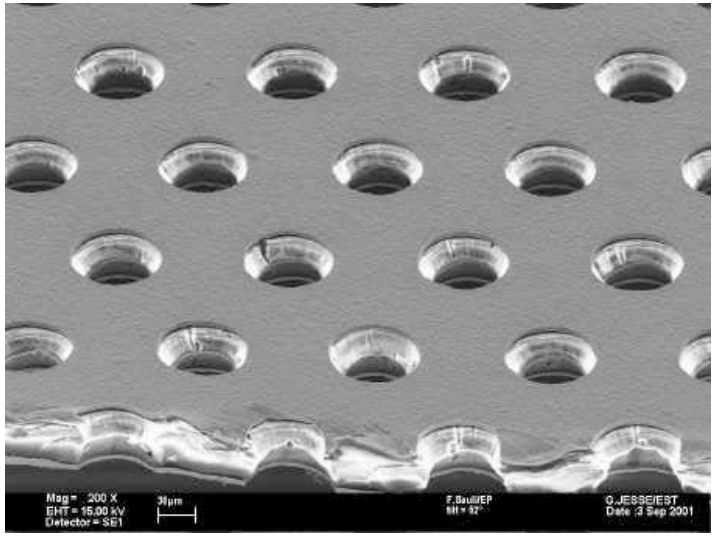
Metal etching

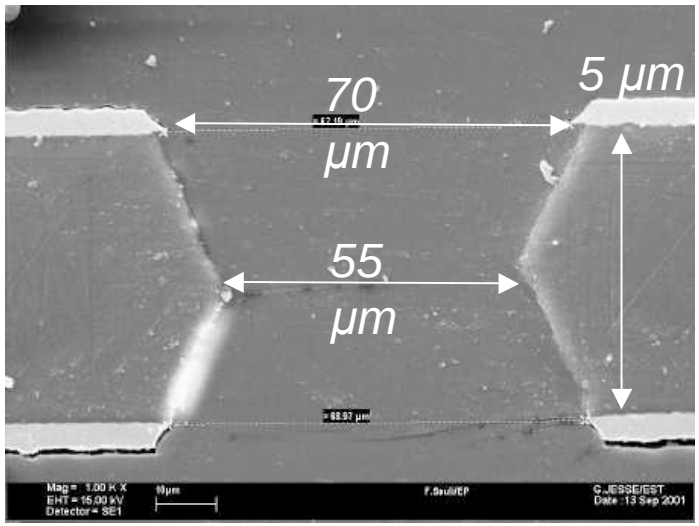
Kapton etching

Second masking

Metal etching and cleaning

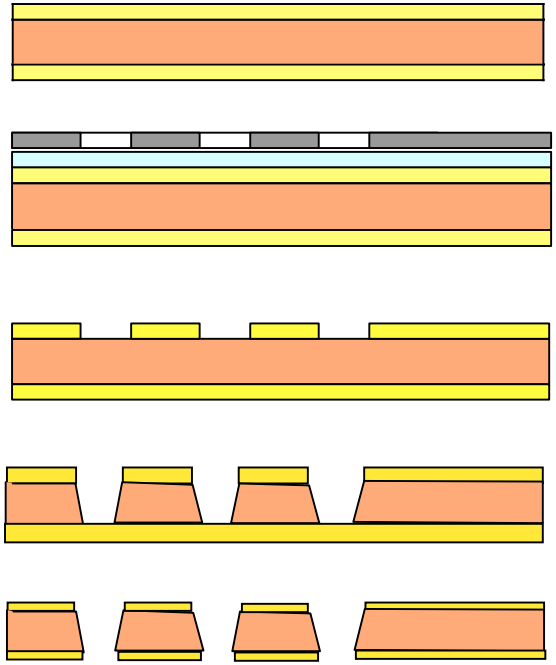




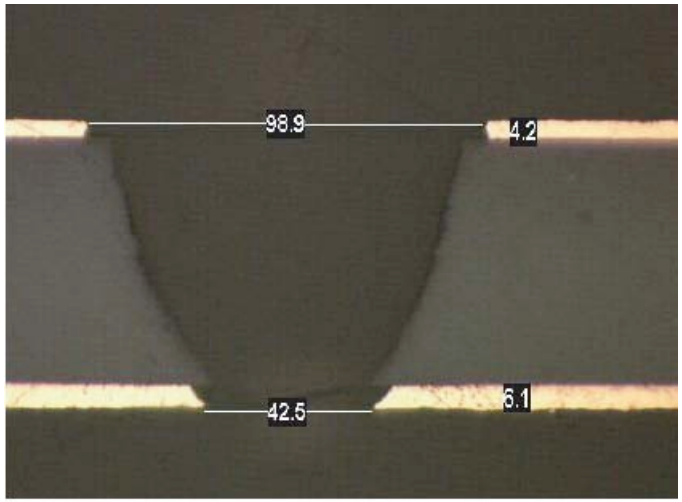


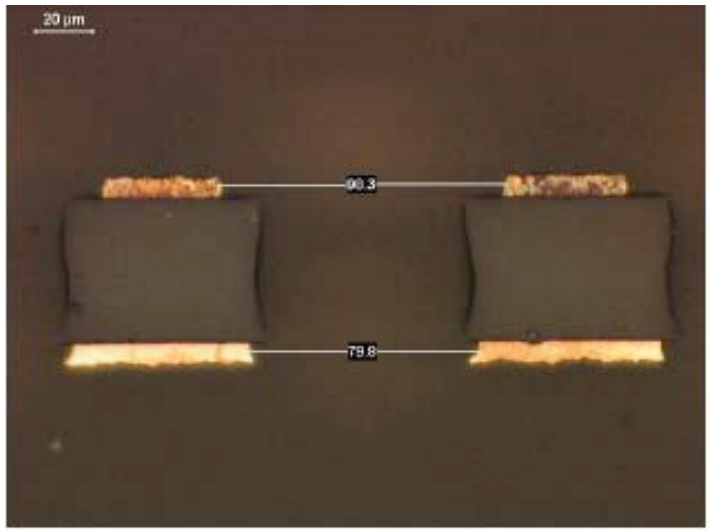
F. Sauli, Nucl. Instr. and Meth. A386(1997)531

SINGLE MASK PROCESS



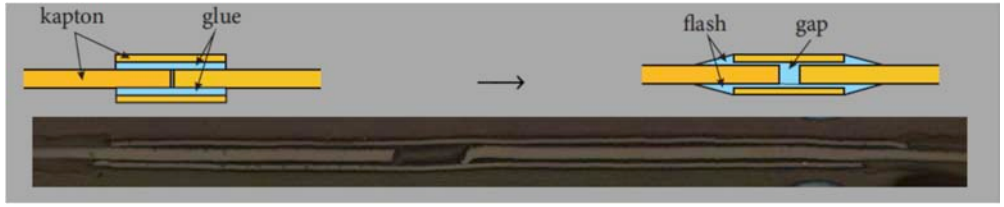
R. De Oliveira, MPGD Int. Conf. (Crete, June 12-15, 2009)



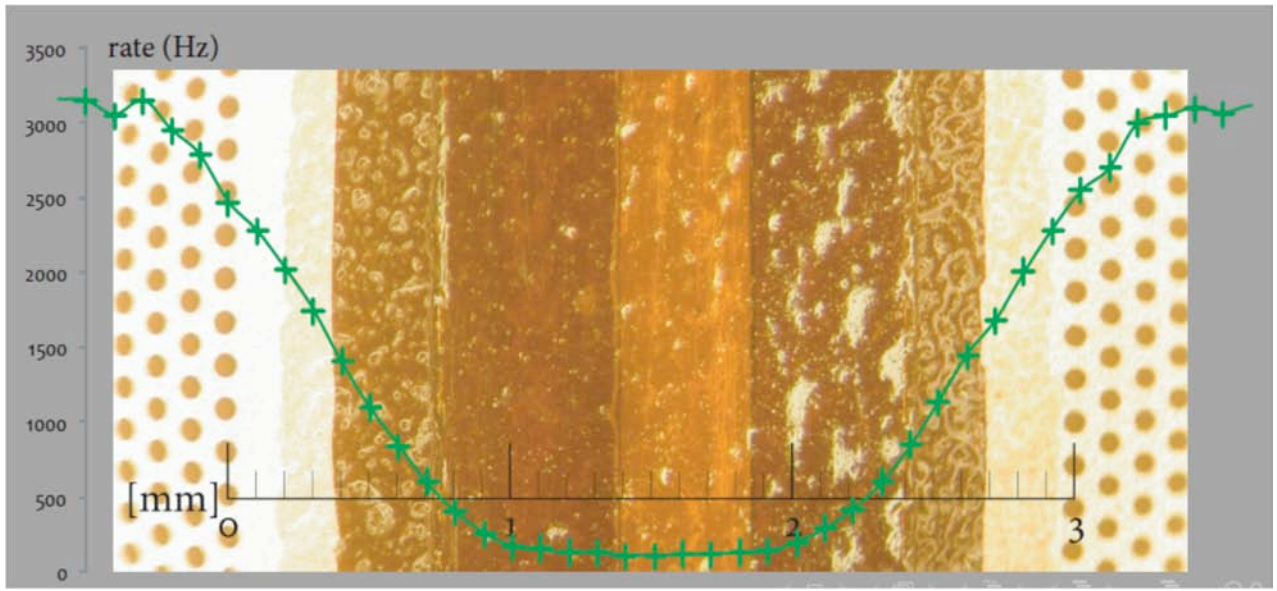


S. Duarte Pinto et al,
IEEE Nucl. Sci. Symp. Conf. Rec. (Dresden, Oct. 2008)

SPLICING: JOINING GEM FOILS

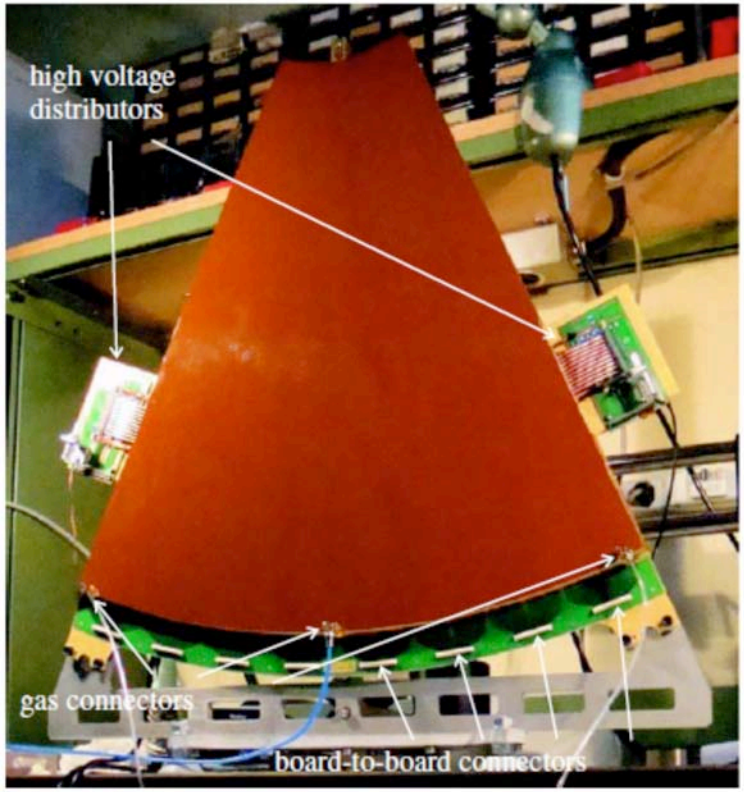


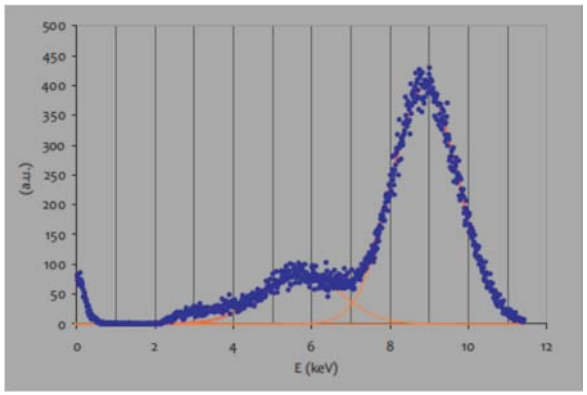
EFFICIENCY SCAN ACROSS JOINT:



S. Duarte Pinto et al, IEEE Nucl. Sci. Symp. Conf. Rec. (Dresden, Oct. 2008)

LARGE GEM DETECTOR



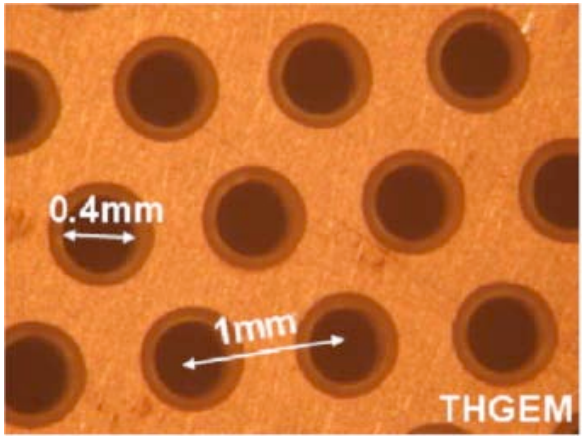


S. Duarte Pinto et al,
IEEE Nucl. Sci. Symp. Conf. Rec. (Dresden, Oct. 2008)

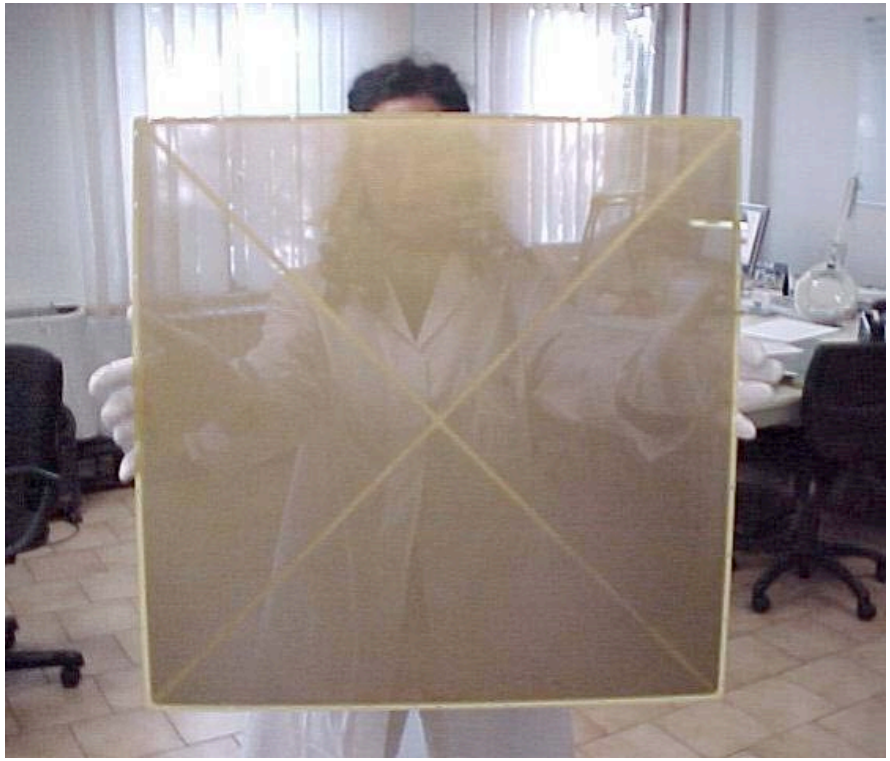
M. Alfosi et al, Nucl. Instr. And Meth. In press (2009)

MECHANICAL DRILLING OF METAL-CLAD PC BOARD
- **SELF-SUPPORTING**
- **HIGH GAIN**

R.Chechik et al, Nucl. Instr. and Meth. A535(2004)303



LARGE TGEM: INFN TRIESTE: 60x60 cm^2

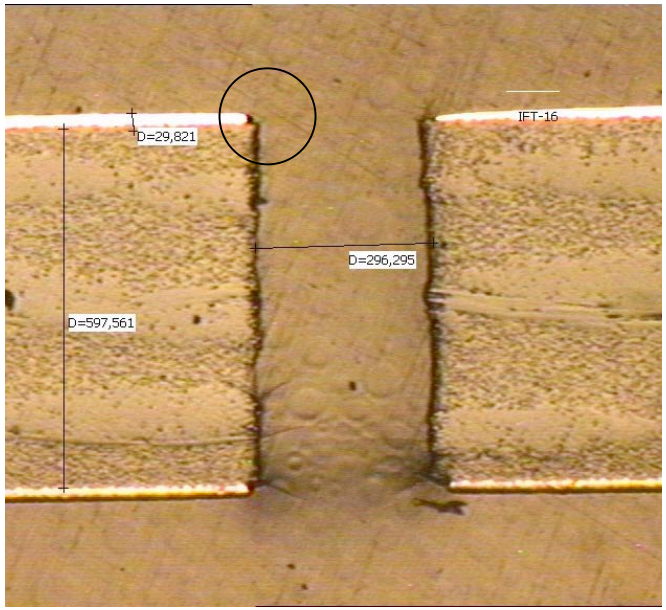


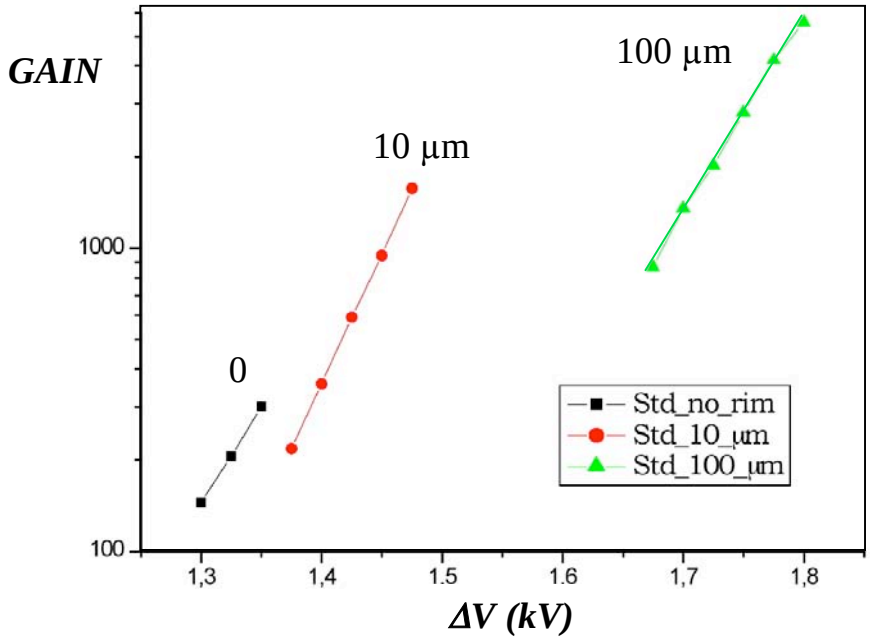
WEIZMANN INSTITUTE: 30x30 cm^2

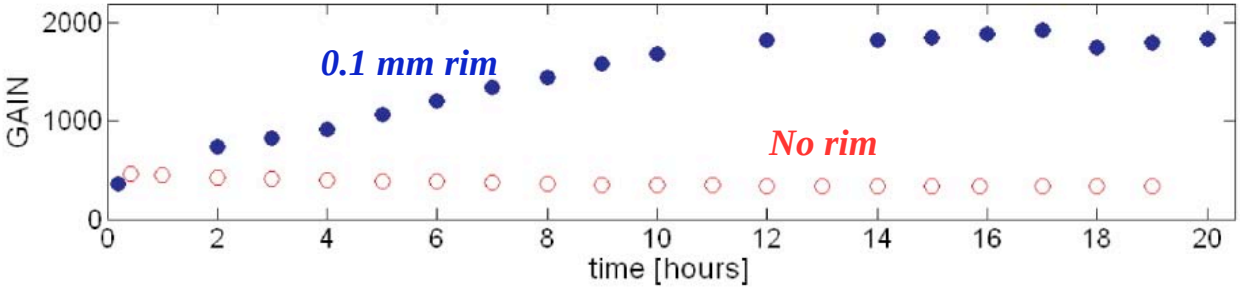
LARGE RIM:
- **HIGH GAIN**
- **LARGE CHARGING UP**

RIMLESS:
- **LOW GAIN**
- **STABLE**

Single TGEM
0.4 mm thick 0.4 mm Ø holes, 0.8 mm pitch:

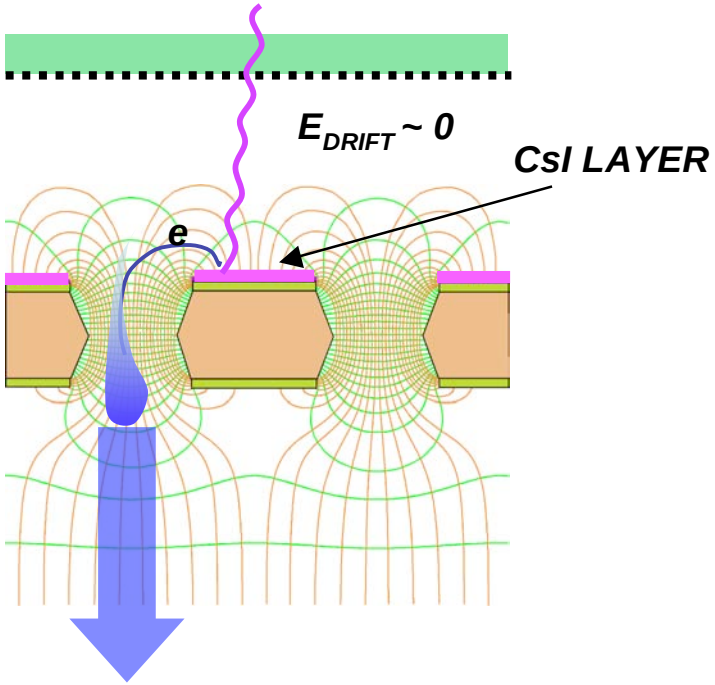






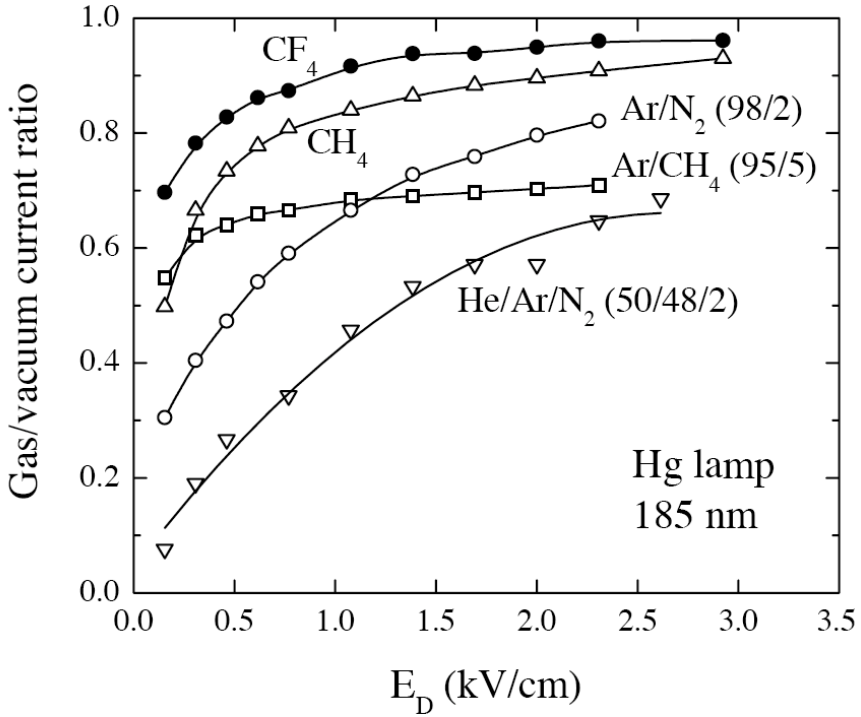
S. Dalla Torre, Int. Conf. on Technology and Instrumentation in Particle Physics (TIPP09, Tsukuba March 12-17, 2009)

PHOTOSENSITIVE GEM



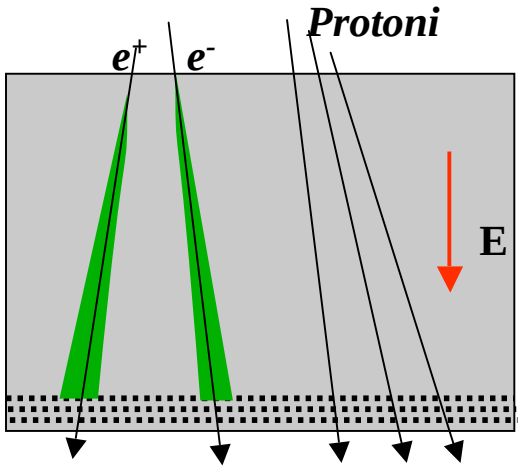
D. Mormann et al,
Nucl. Instr. and Meth. A478(2002)230

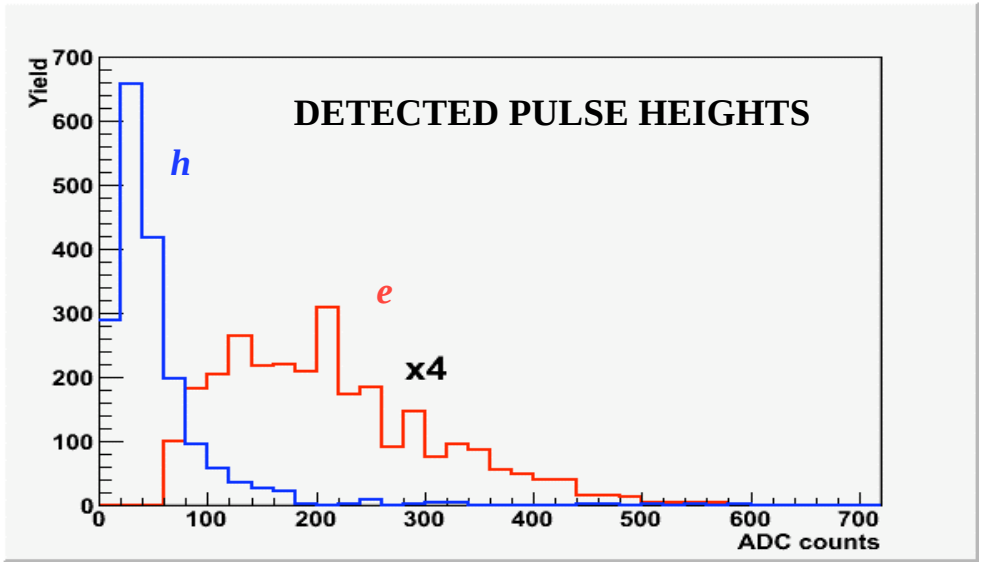
RELATIVE QUANTUM EFFICIENCY AS A FUNCTION OF EXTRACTION FIELD

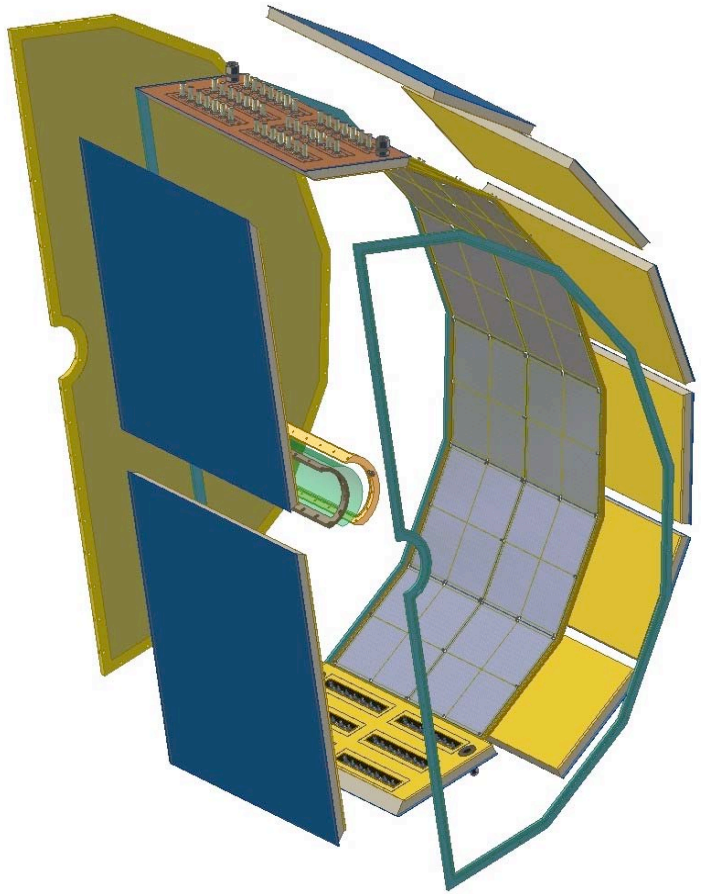


A. Breskin et al, Nucl. Instrum. Methods A483(2001)670

PHENIX HADRON BLIND





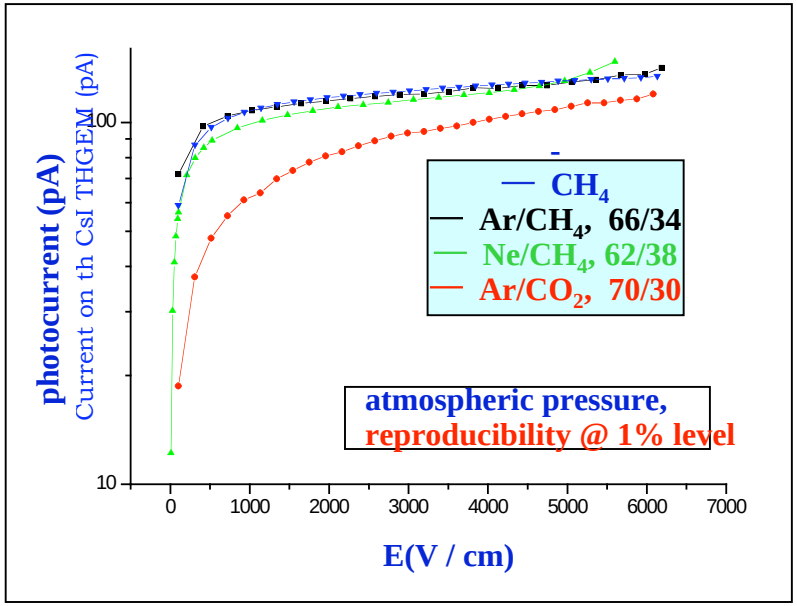


C. Aidala et al, Nucl. Instr. Methods A502(2003)200
Z. Fraenkel et al, NIMA 546(2005) 466

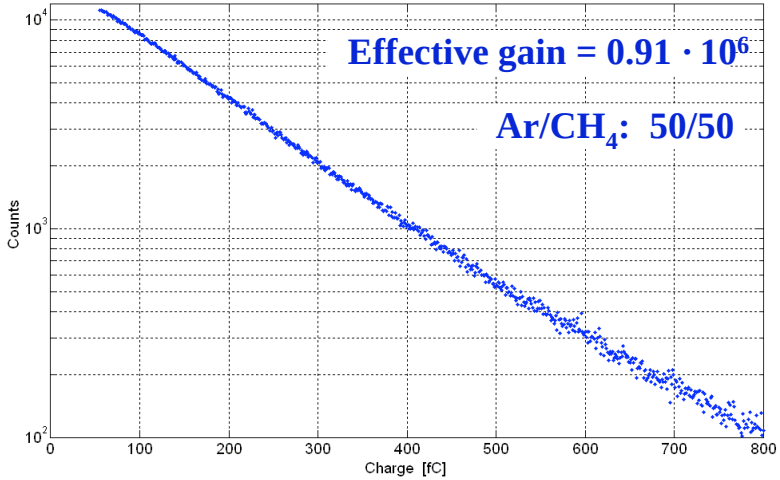
THICK GEM FOR PHOTON DETECTION

CsI photocathode

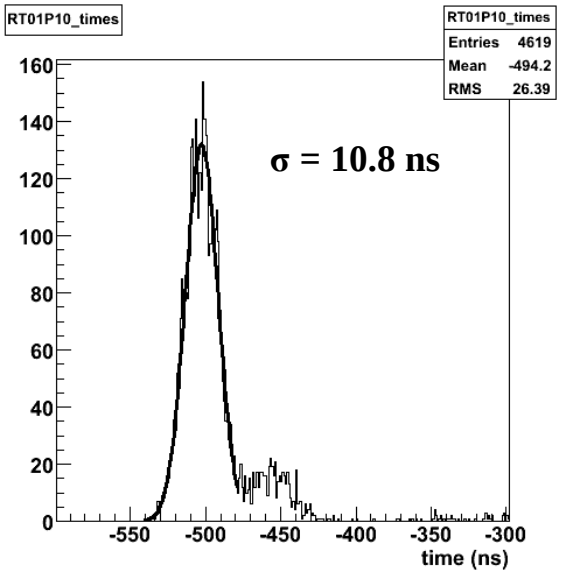
RELATIVE QUANTUM EFFICIENCY VS FIELD



Triple TGEM: Single photon PH spectrum



TIME RESOLUTION:



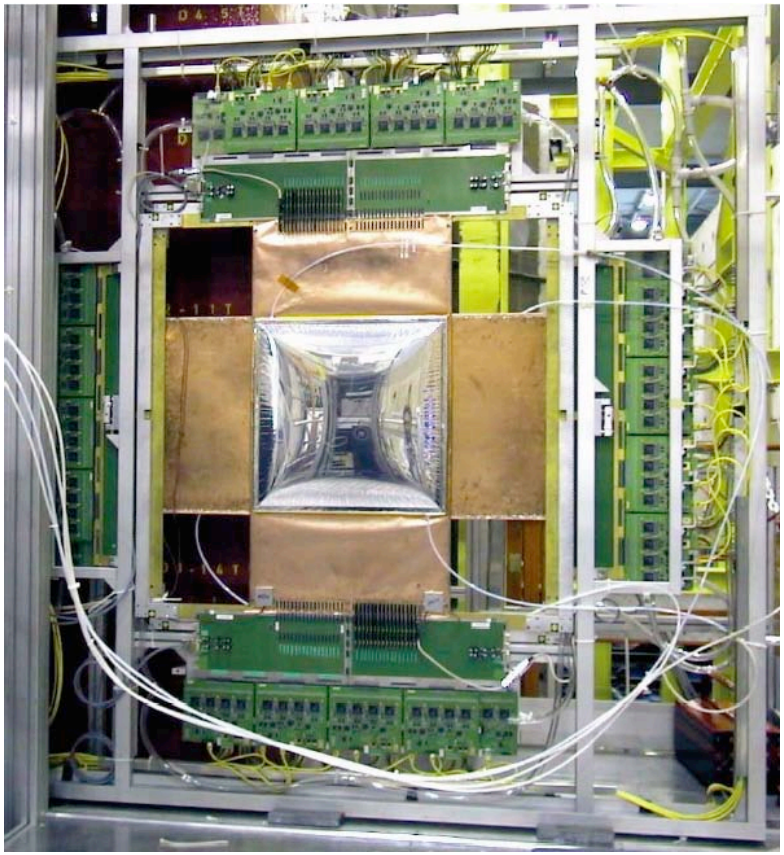
M.Alexeev et al, Nucl. Instr. And Meth, In Press (2009)

F. Tessarotto, MPGD Int. Conf. (Crete, June 12-15, 2009)

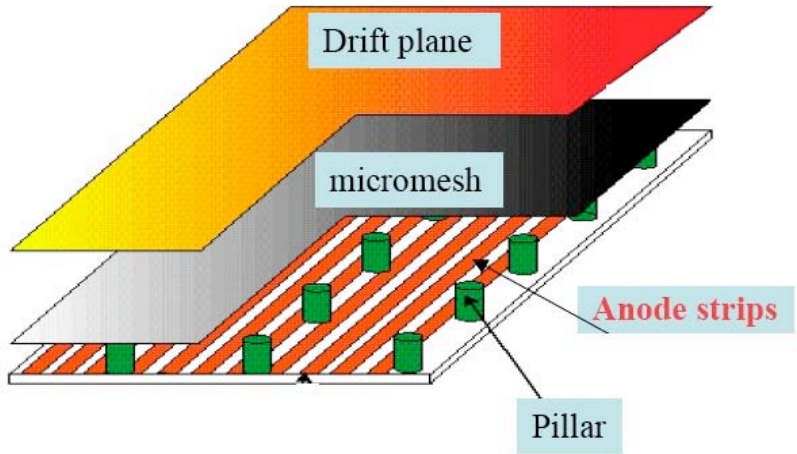
12 PLANES IN 3 STATIONS X,Y, U, V

40x40 cm^2 active

350 µm strips with digital readout

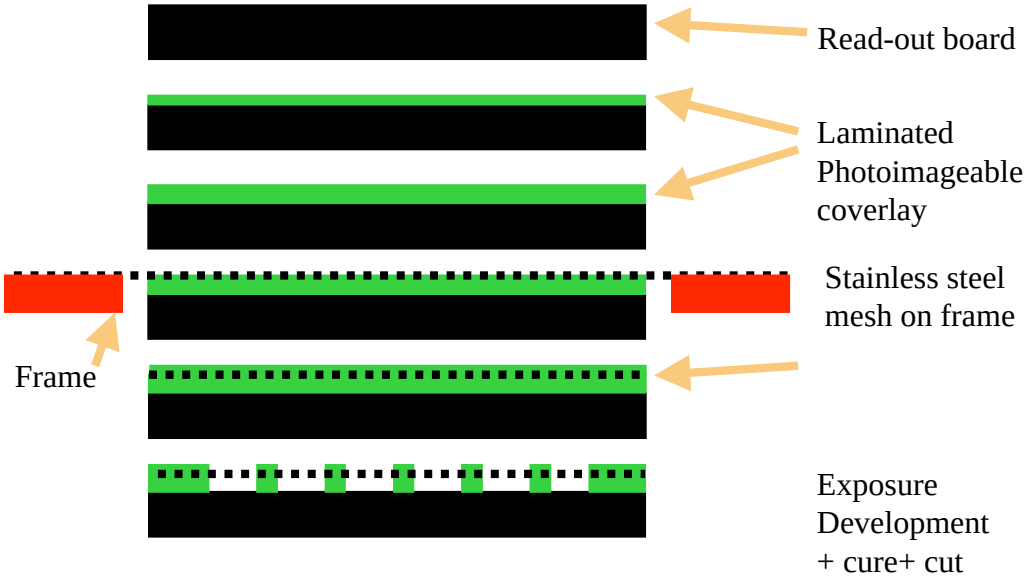


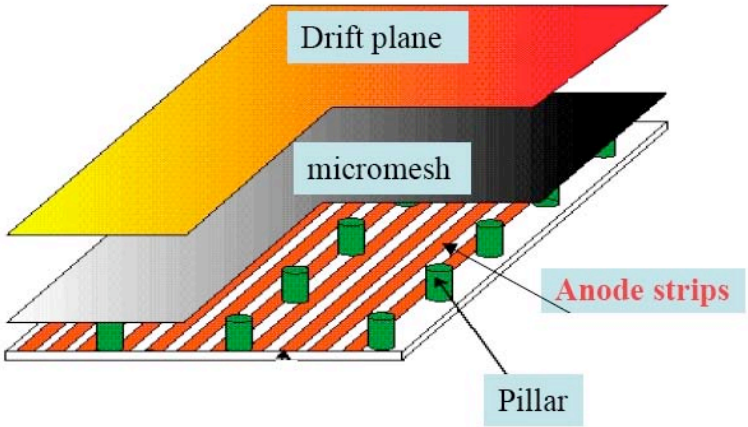
MICROMESH OVER PILLARS OR FISHING LINE SPACERS:

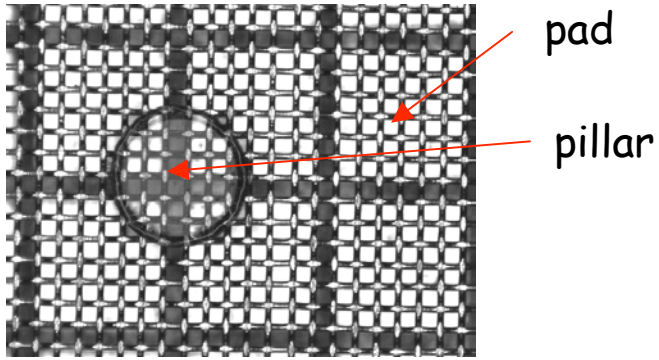


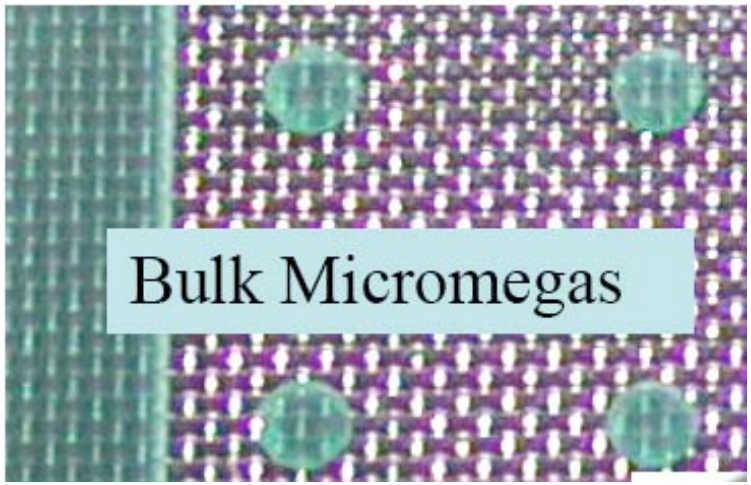
C. Bernet et al, Nucl. Instr. and Meth. A536(2005)61

BULK MICROMEGAS







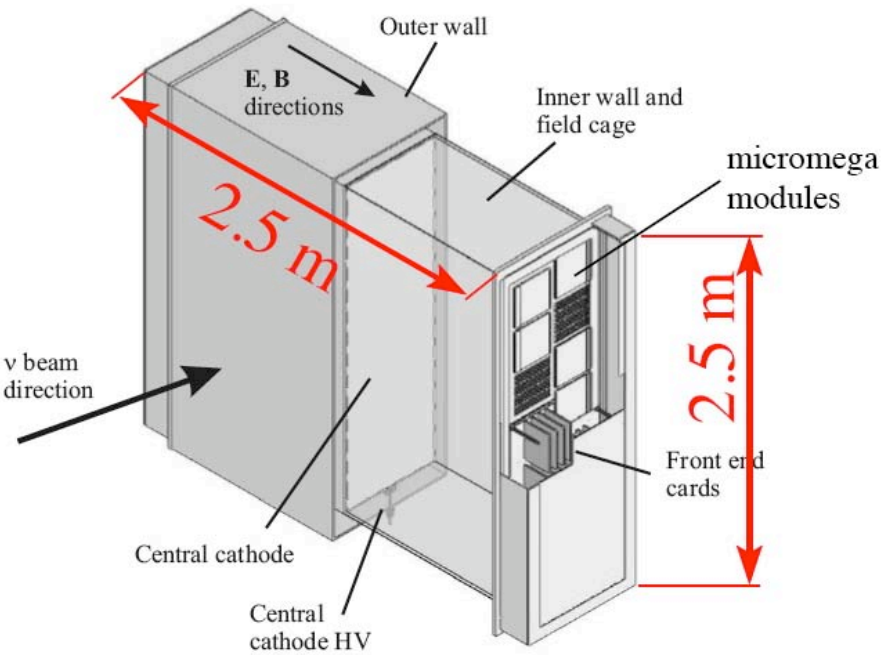


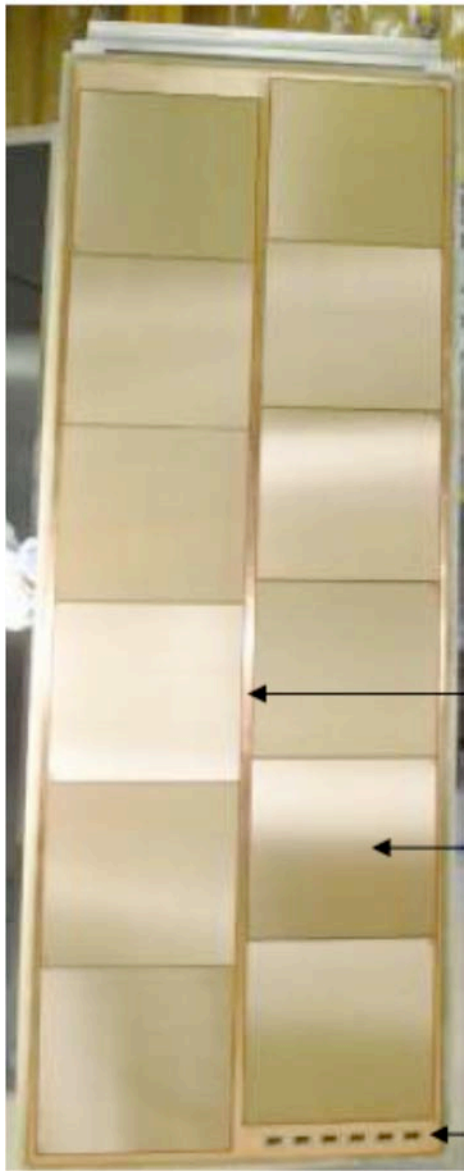
I. Giomataris et al, Nucl. Instr. and Meth.A560(2006)405

J. Bouchet et al, Nucl. Instr. and Meth. A574(2007)425

72 MICROMEGAS MODULES (35x36 cm^2)

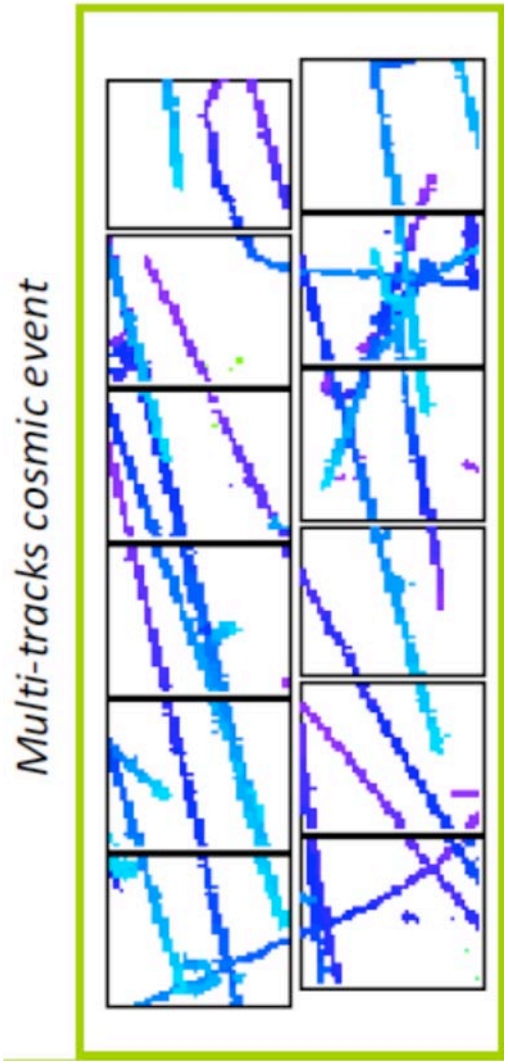
READOUT: 36x48 PADS of 9.7x6.9 mm^2





A. Delbart, Int. Conf. on Technology and Instrumentation in Particle Physics (TIPP09, Tsukuba March 12-17, 2009)

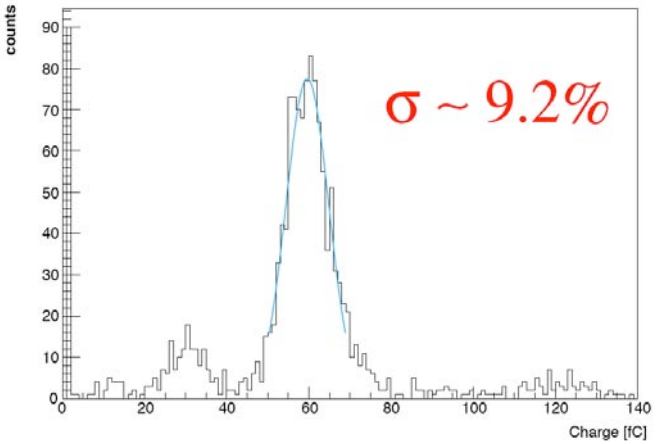
J. Beucher, MPGD Int. Conf. (Crete, June 12-15, 2009)



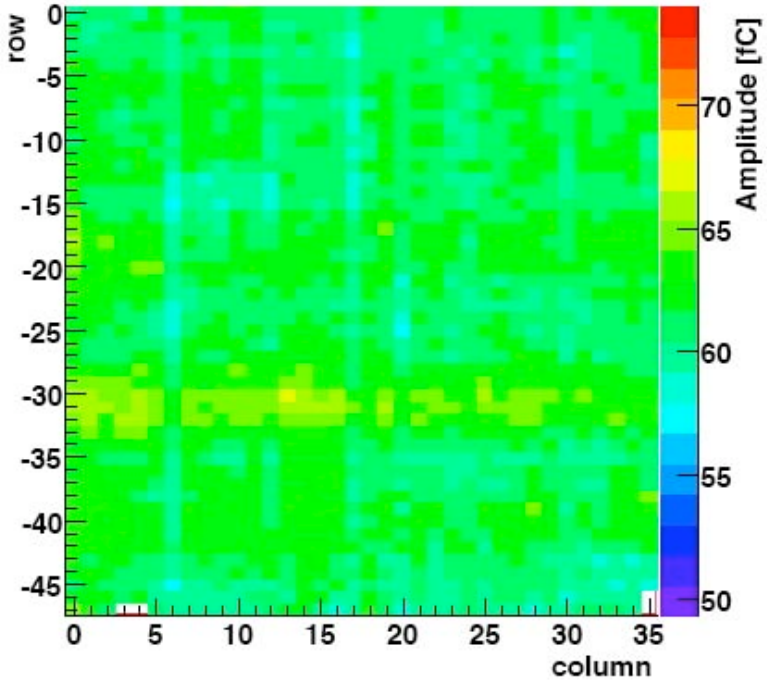
J. Beucher, MPGD Int. Conf. (Crete, June 12-15, 2009)

ENERGY RESOLUTION ON ^{55}Fe:

1728 PADS

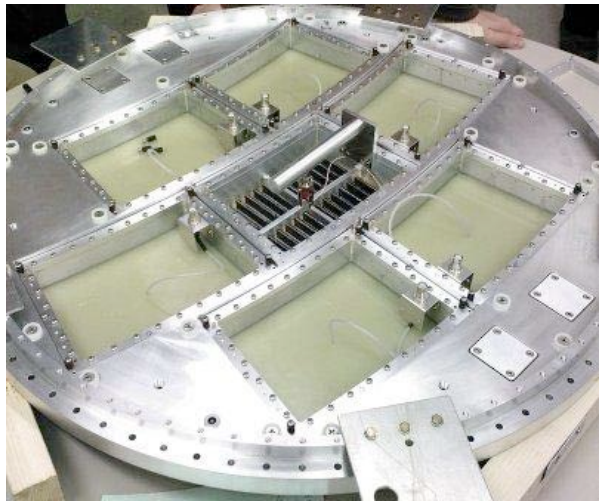


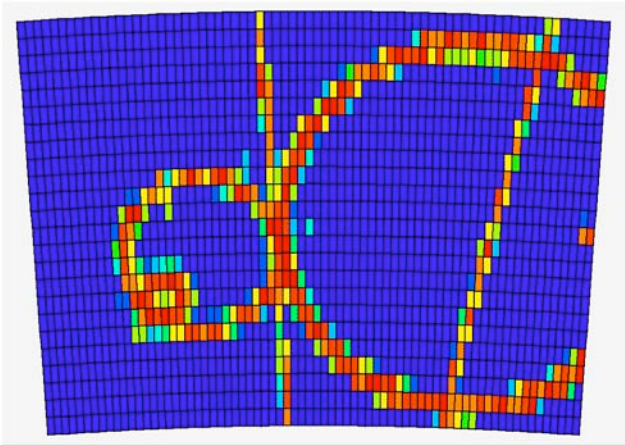
GAIN UNIFORMITY: ~ 2% RMS



MPGD READOUT FOR THE INTERNATIONAL LINEAR COLLIDER TPC

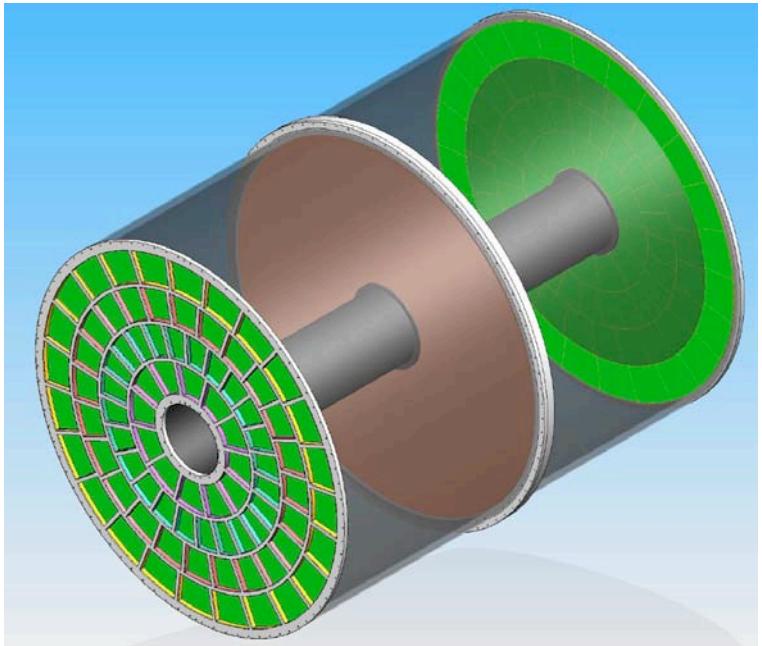
COMPOSITE END-PLATE ASSEMBLY



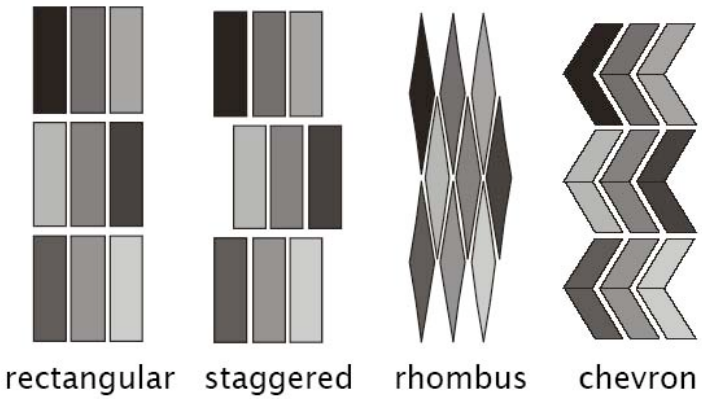


P. Colas and K. Dehmelt, Int. Conf. on Technology and Instrumentation in Particle Physics (TIPP09, Tsukuba March 12-17, 2009)

MICROMEGAS MODULE 17X21 CM^2 ACTIVE



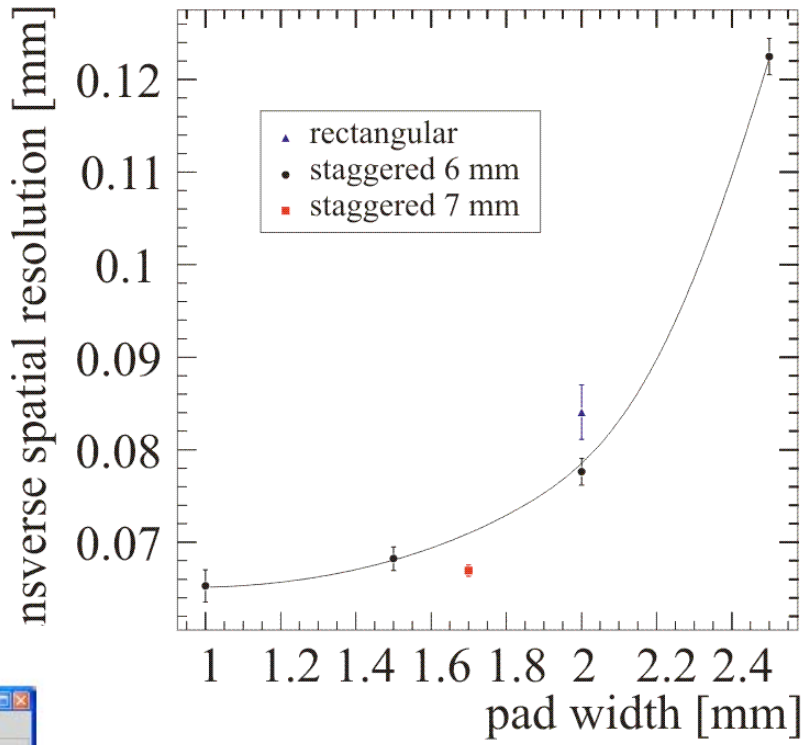
OPTIMIZATION OF PAD SIZE & SHAPE

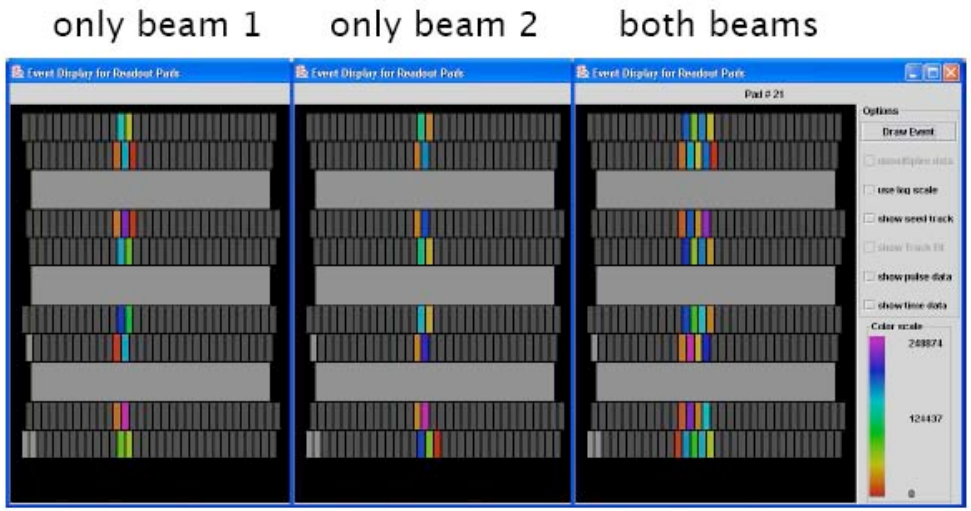


J. Kaminski, LBL TPC Workshop (Berkeley 7-8 April 2006)

B. Ledermann et al, Nucl. Instr. and Meth. A581(2007)232

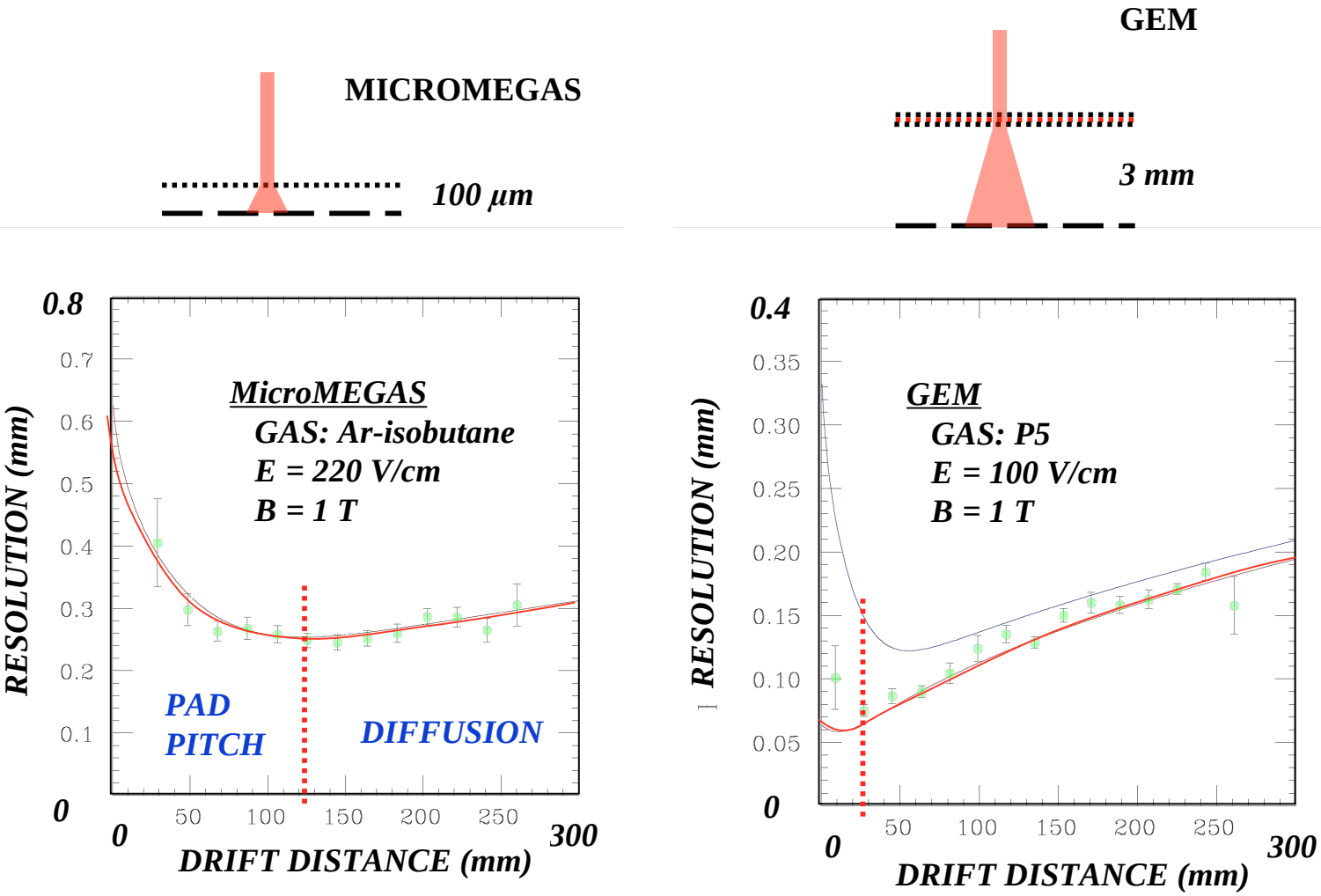
RESOLUTION VS PAD WIDTH:





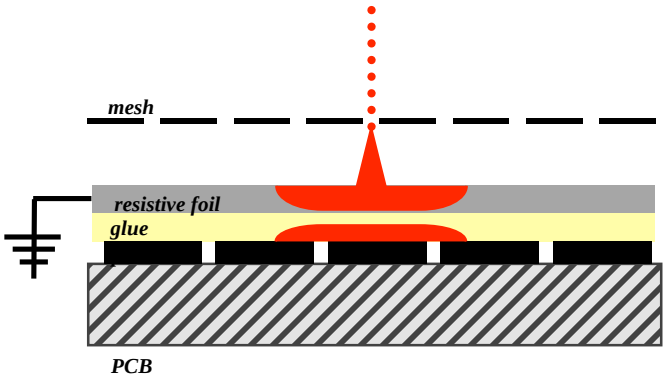
TWO-TRACK RESOLUTION STUDIES WITH LASER BEAMS (Victoria-DESY)

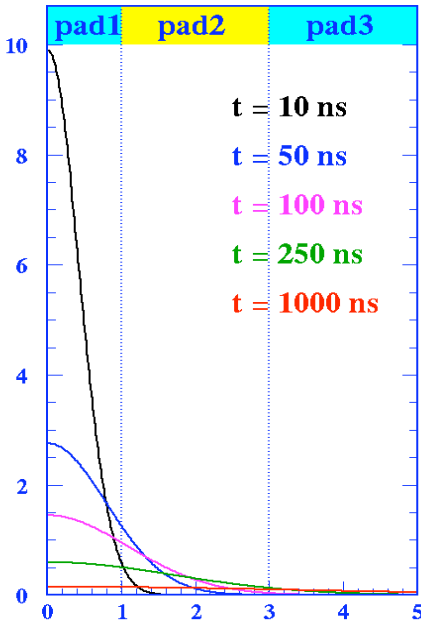
PAD SIZE EFFECT FOR SHORT DRIFT DISTANCES



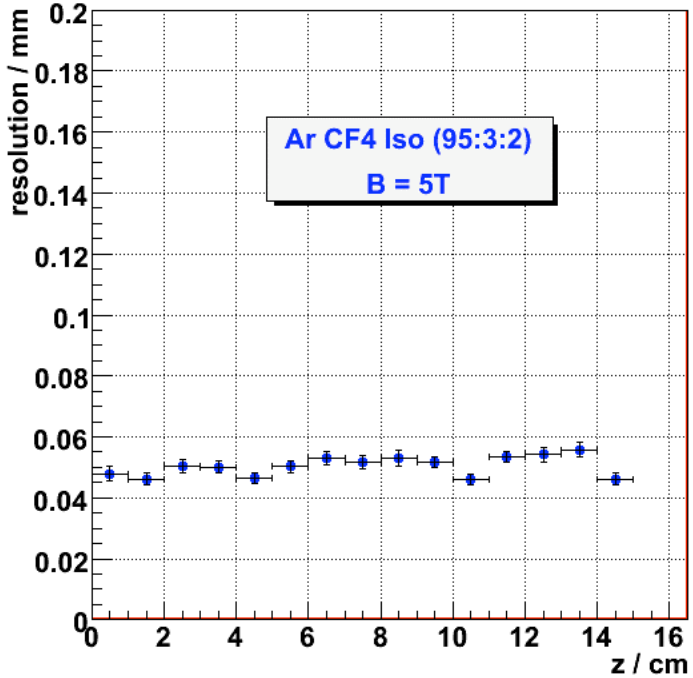
M. Kobayashi et al, Nucl. Instr. and Meth, A581 (2007)265

REDUCE PAD NUMBER: CHARGE SHARING WITH RESISTIVE FOIL ON ANODE





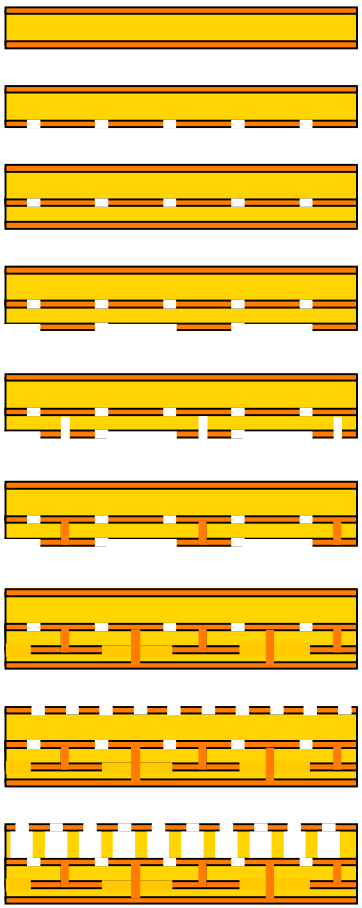
MEASURED RESOLUTION @ 5 TESLA MICROMEGAS WITH RESISTIVE ANODE:

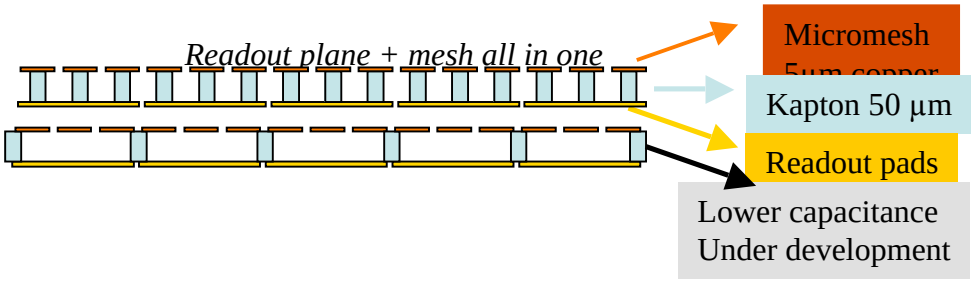


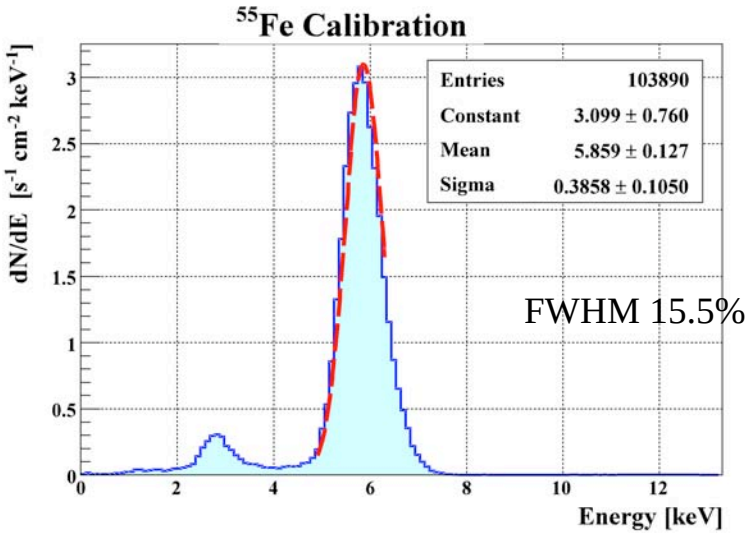
M. Dixit et al, Nucl. Instr. and Meth. A566((2006)281

K. Boudjemline et al, Nucl. Instr. and Meth.A574(2007)22

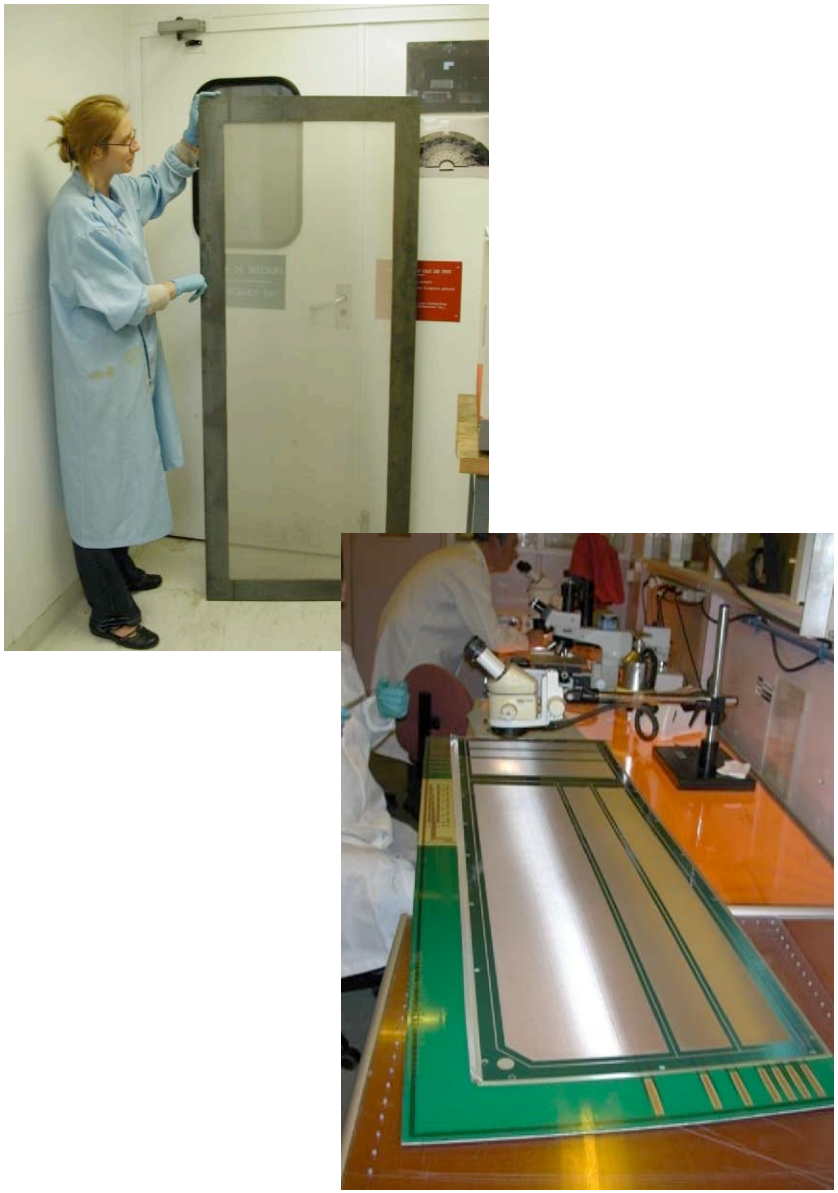
MICROBULK MICROMEGAS



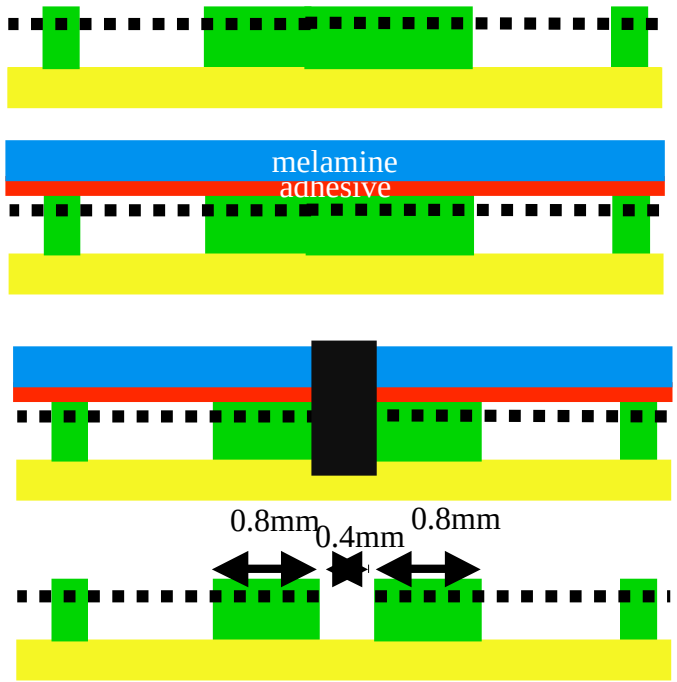




T. Papaevangelou, MPGD Int. Conf. (Crete, June 12-15, 2009)

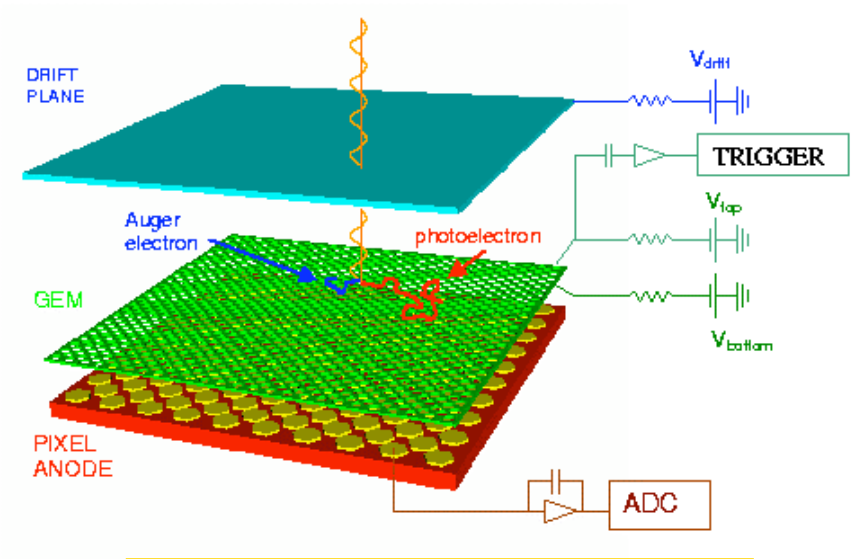


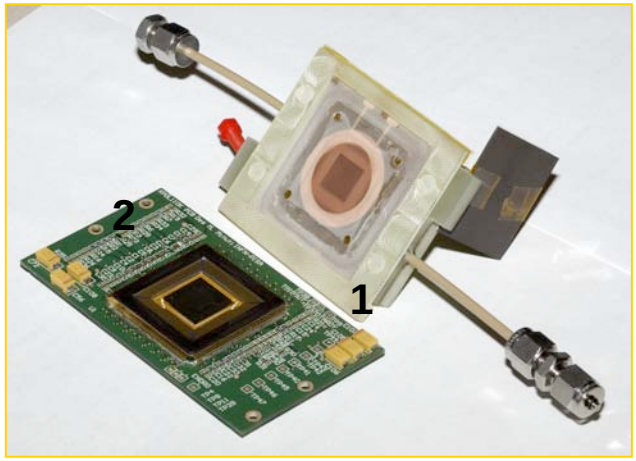
MICROMEGAS SECTORING:

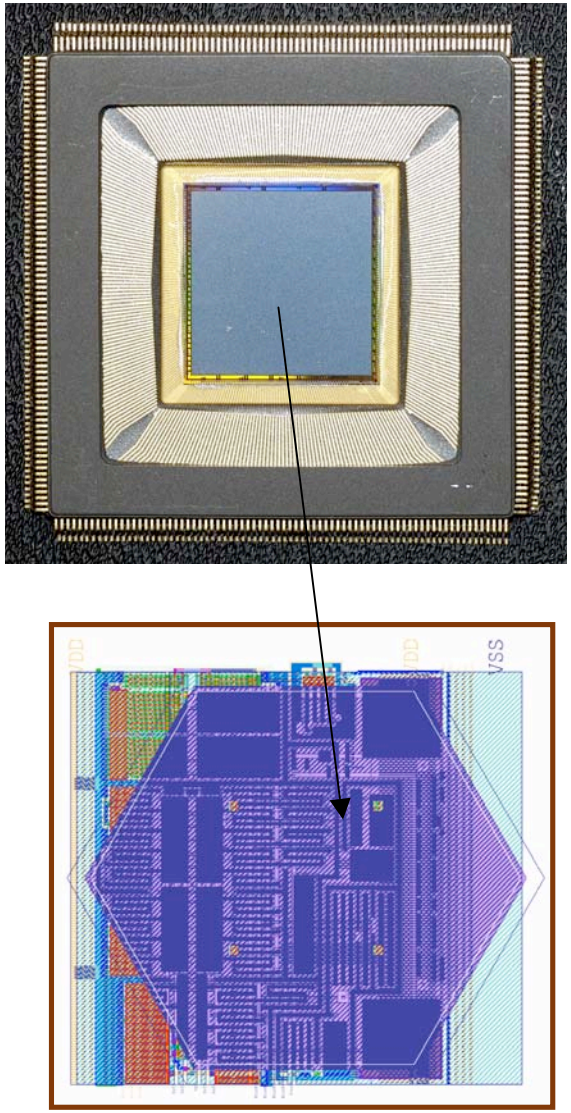


R. De Oliveira, RD-51 Mini-Week (CERN 23-24.9.09)

GEM X-RAY POLARIMETER

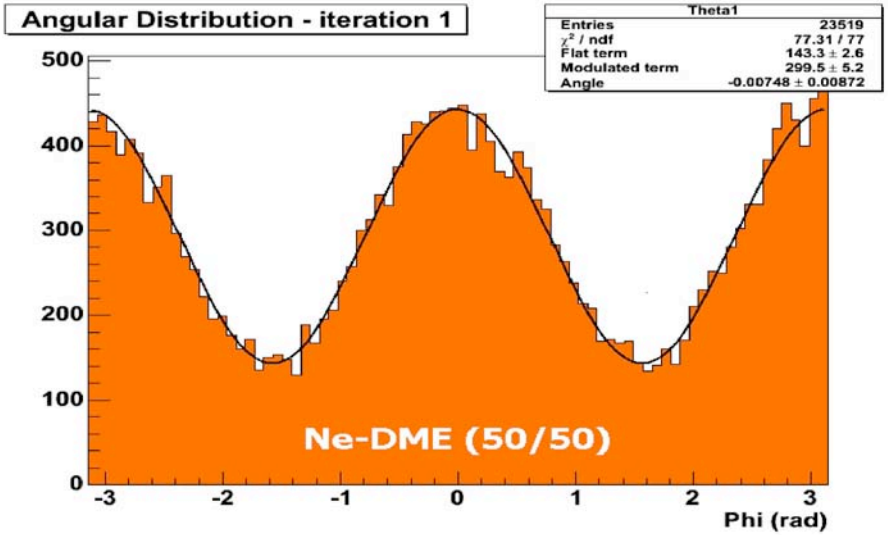


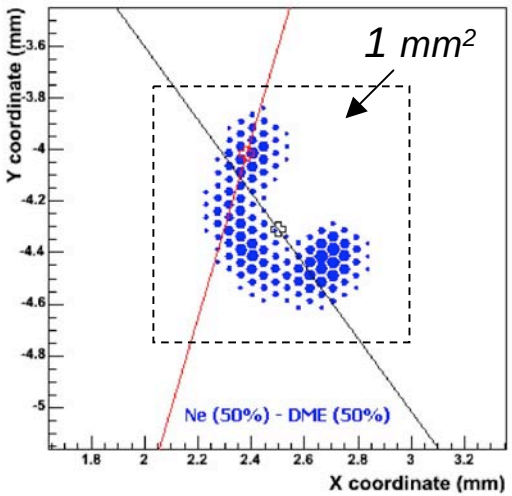


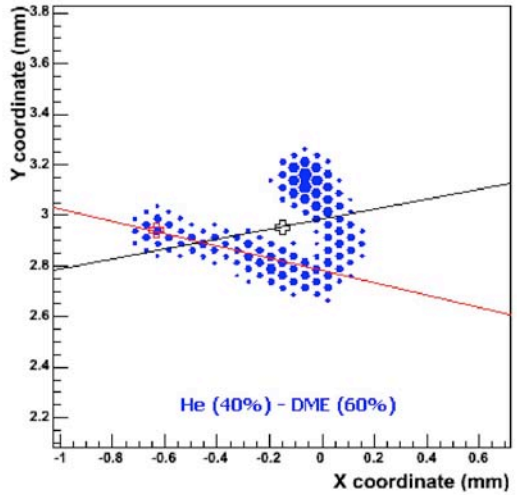


E. Costa et al, Nature 411(2001)662
R. Bellazzini et al, Nucl. Instr. and Meth. A478(2002)13
R. Bellazzini et al, Nucl. Instr. and Methods A435(2004)477

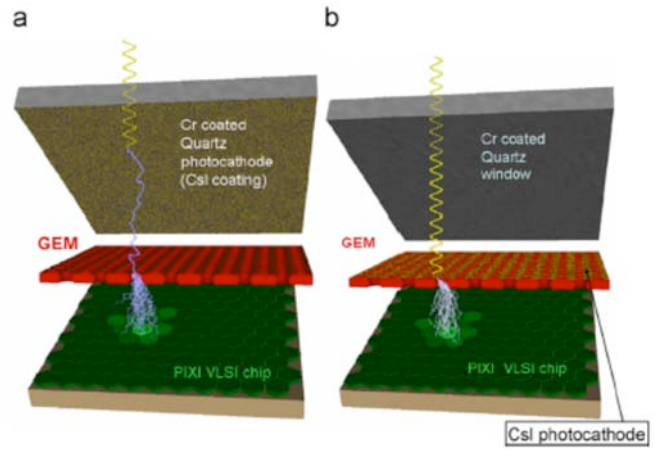
PHOTOELECTRON ANGULAR DISTRIBUTION FOR POLARIZED SOFT X-RAYS:







R.Bellazzini et al, Nucl. Instr. And Meth. A572(2007)160



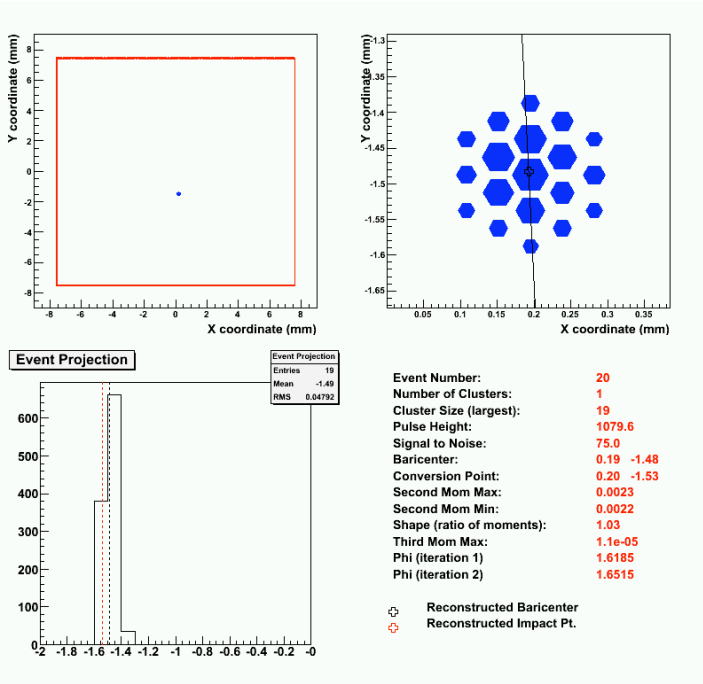
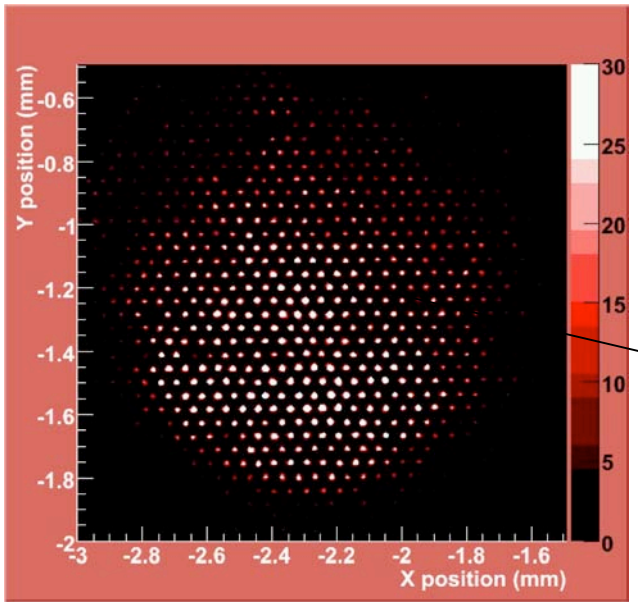
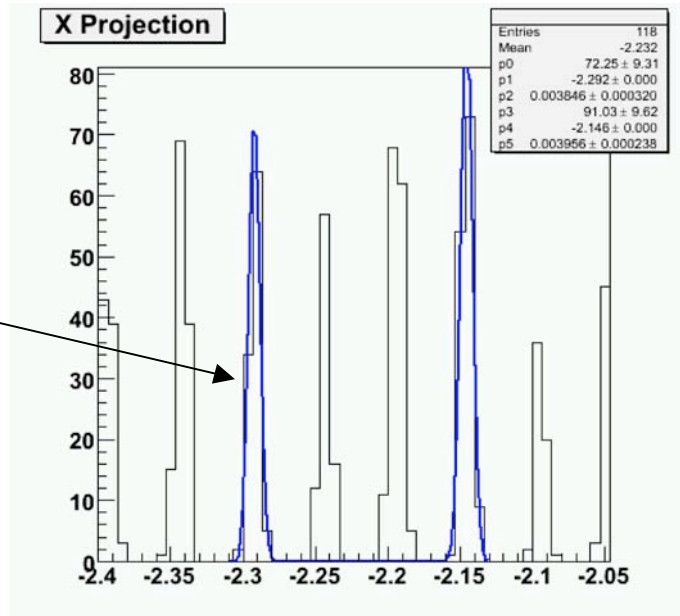


IMAGE OF THE GEM FOIL (30 µm HOLES AT 50 µm PITCH):



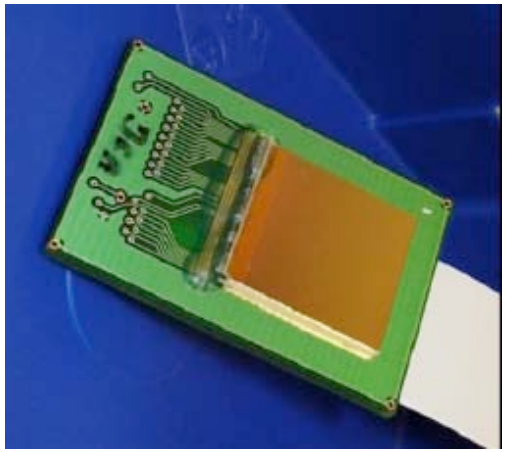
4 µm rms



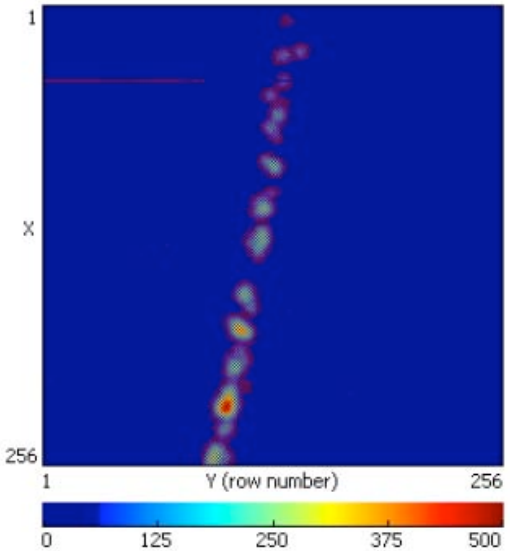
R. Bellazzini et al, Nucl. Instr. And Meth. A581 (2007) 246

TRIPLE GEM TPC WITH SOLID STATE PIXEL READOUT

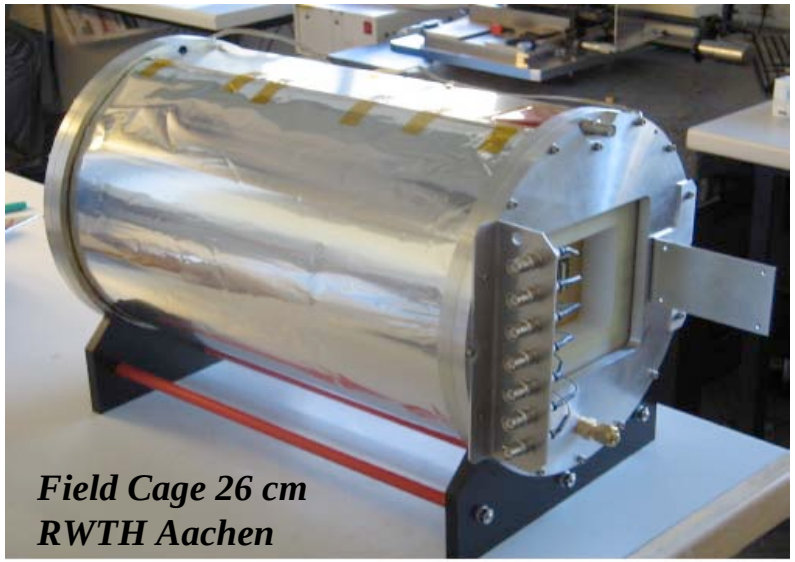
TIMEPIX
256x256 pixels, 55x55μm^2
14x14 mm^2 active area

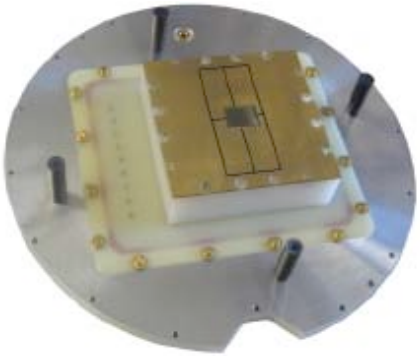


Cosmic track: short Drift

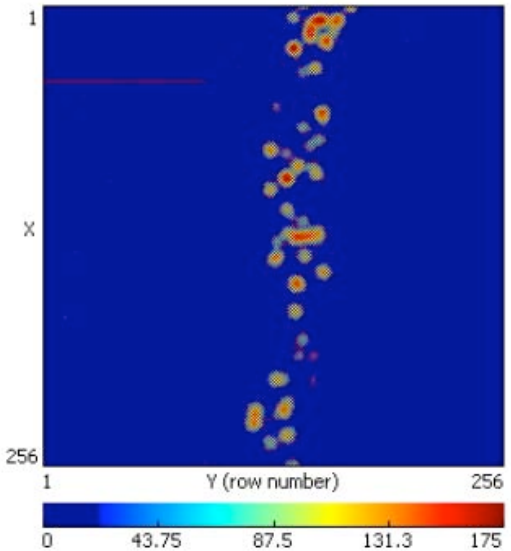


BONN UNIVERSITY ILC-TPC



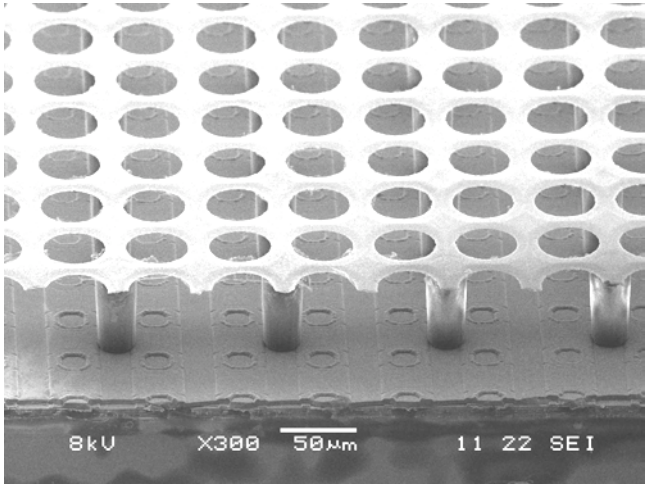


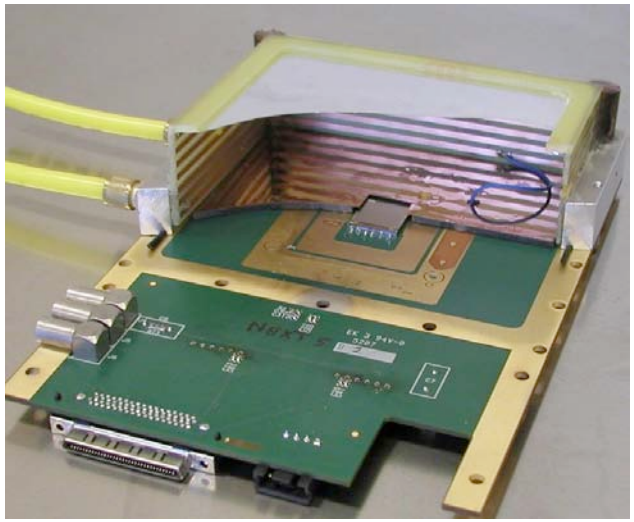
Long Drift:



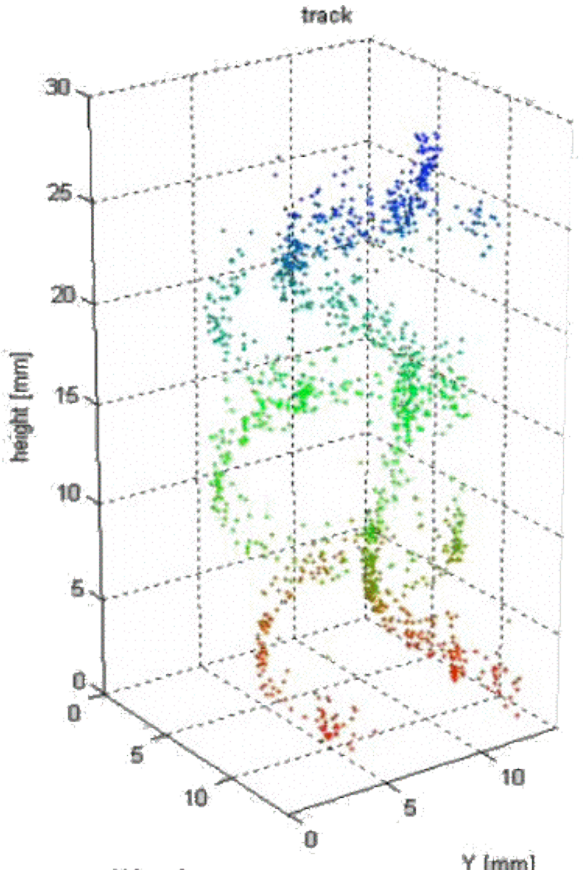
J. Kaminski, RD51 Coll. Meeting (Paris Oct. 13-15, 2008)

INTEGRATED MICROMEGAS AND PIXEL SENSOR
Postprocessing of the TIMEPIX chip to build a metal mesh on insulating pillars





ELECTRON TRACKS FROM ^{90}Sr IN MAGNETIC FIELD (0.2 T):



H. Van der Graaf ,
IEEE Nucl. Sci. Symp. Conf. Rec. (Dresden, October 2008)

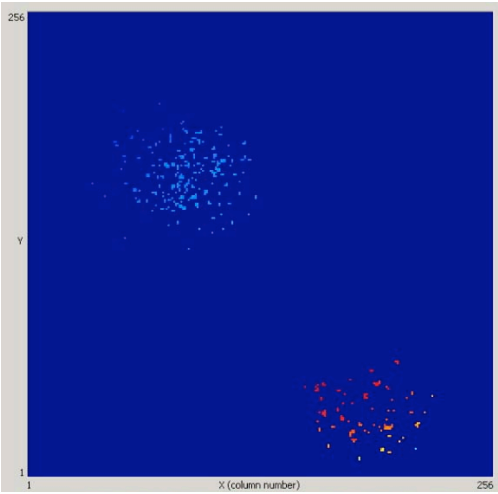
I. Timmermans, Int. Conf. on Technology and Instrumentation in Particle Physics (TIPP09, Tsukuba March 12-17, 2009)

INTRINSIC ENERGY RESOLUTION

Due to low pixel capacitance and noise, the device can detect individual electrons released in the gas by an X-ray source.The pixel count provides the best energy resolution (close to the statistical limit):

$$\left(\frac{\sigma_E}{E}\right)^2 = \frac{F}{N}$$

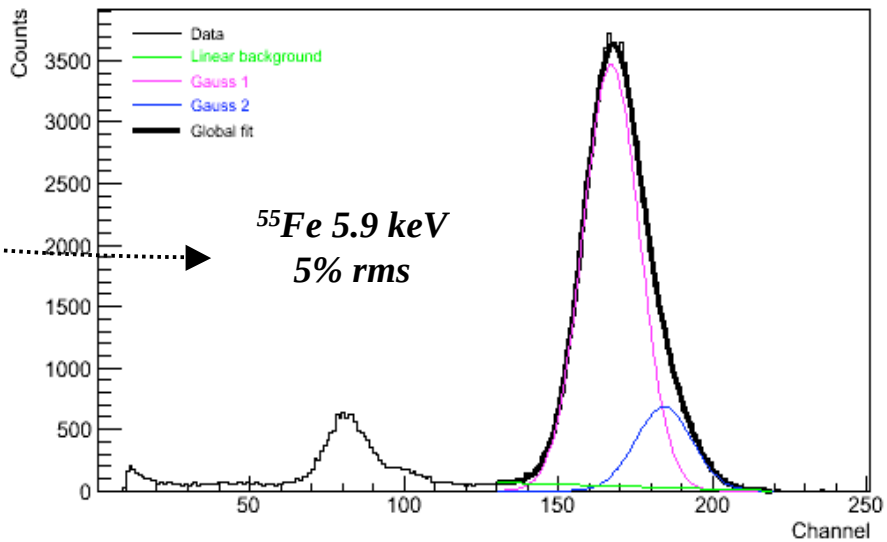
F: Fano factor



For 5.9 keV in Argon-iC_4H_{10}
N≈220, F~0.21

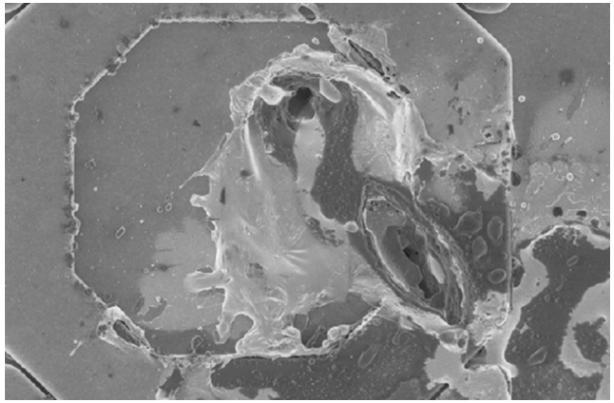
$$\frac{\sigma_E}{E} \approx 3.1\%$$

^{55}Fe X-RAYS CONVERSIONS IN ARGON

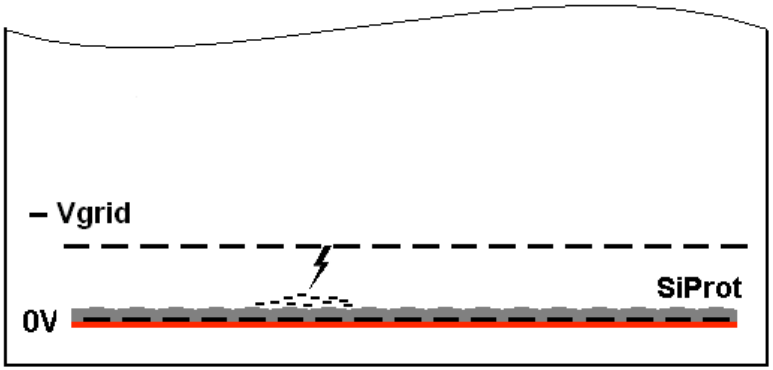


P. Colas, IEEE Nucl. Sci. Symp. Conf. Rec. (Dresden, Oct. 2008)

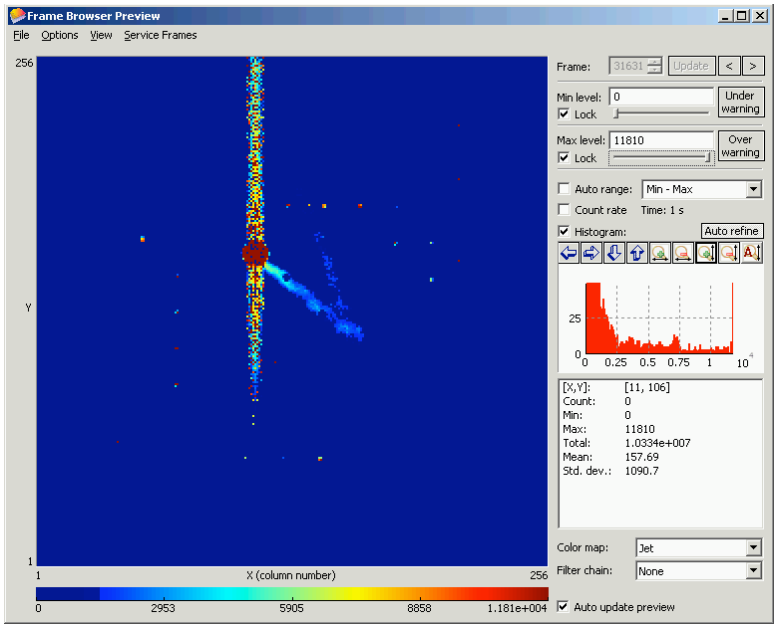
SPARK DAMAGES
GRIDPIX PIXEL AFTER A DISCHARGE:



AMORPHOUS SILICON DEPOSIT (SiProt)



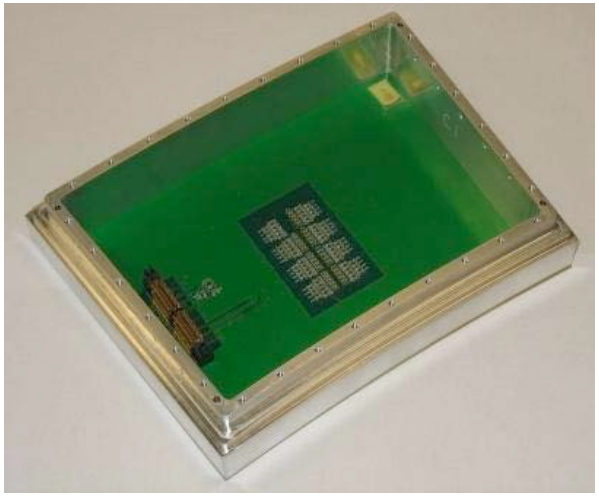
ALPHA DISCHARGE QUENCHING



M. Franzen, RD51 Coll. Meeting (Paris Oct. 13-15, 2008)

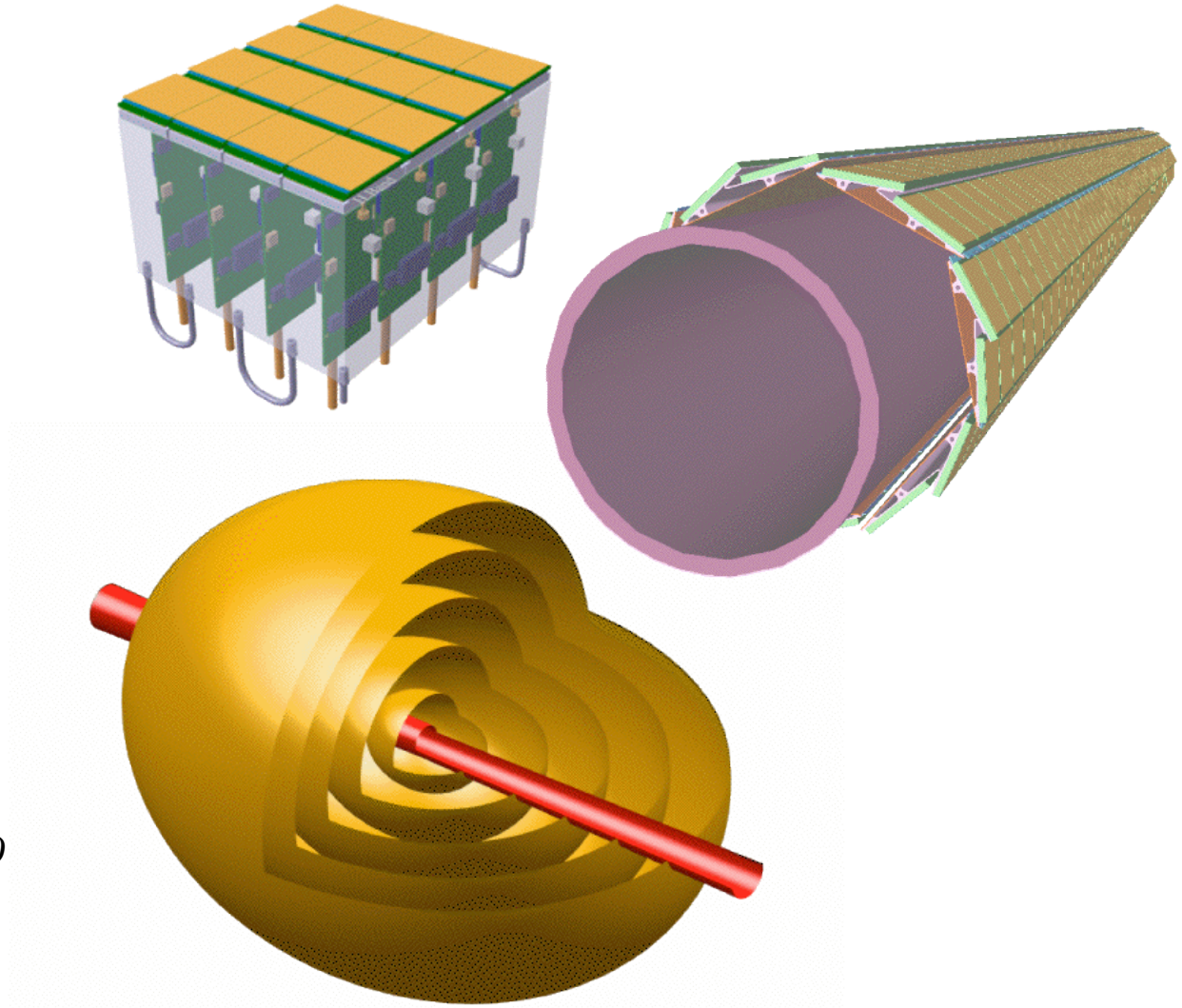
DIGITAL TPC FOR ILC

8 TIMEPIX



T. Matsuda,
RD51 Coll. Meeting (Paris Oct. 13-15, 2008)

GOAT: GOSSIP in ATLAS



H. van der Graaf, IEEE Nucl. Sci. Symp. (Dresden, Oct. 2008)

END OF THE LECTURES...

...BUT NOT OF THE FUN !