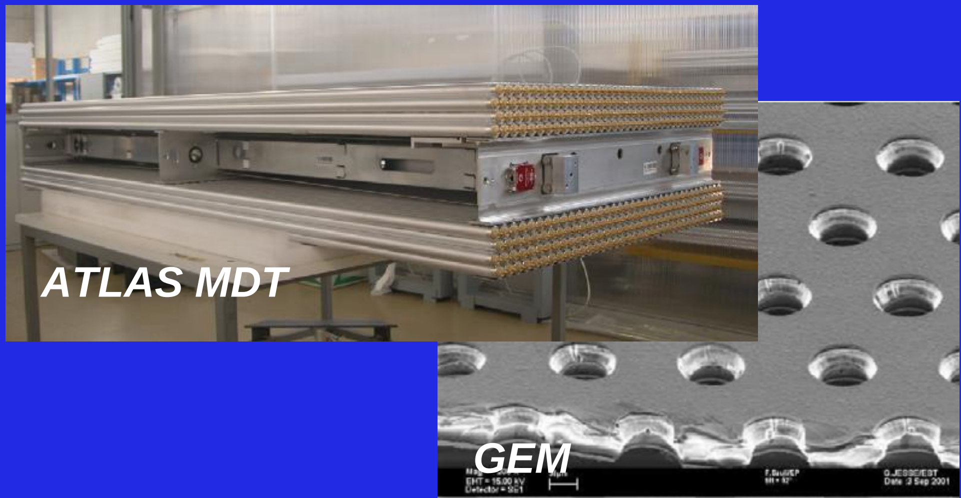
CONFERENCE HIGHLIGHTS

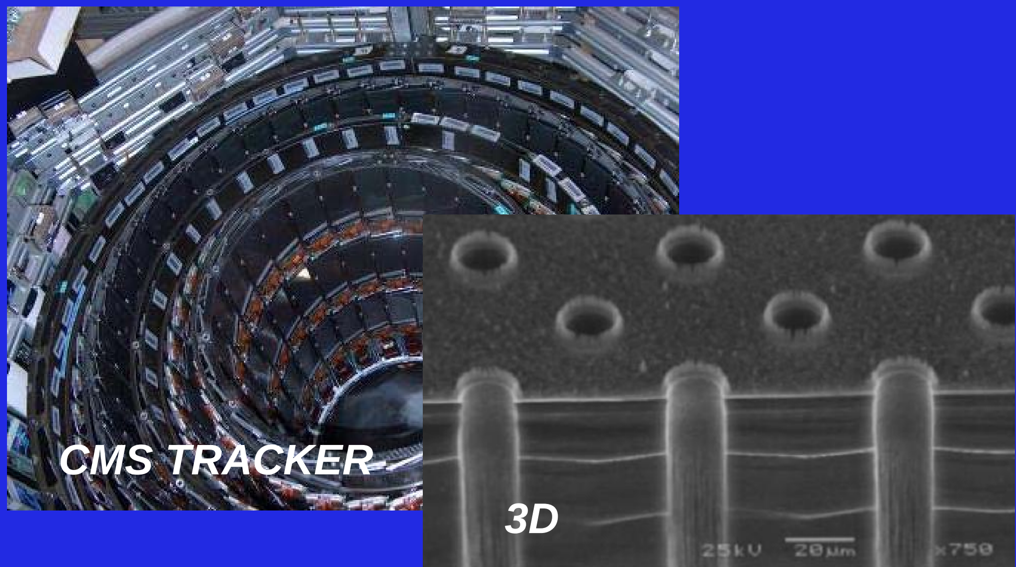
Fabio SAULI
INFN Trieste
TERA Foundation
CERN

CONTRIBUTIONS BY SUBJECT:



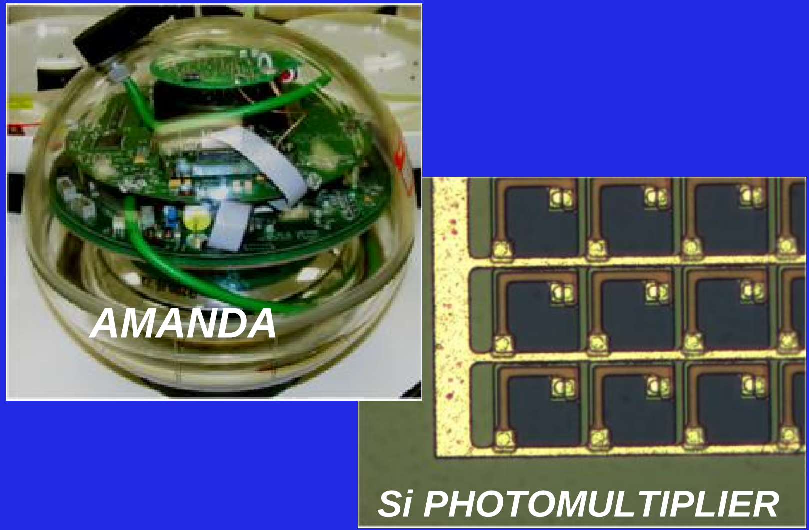
GASEOUS DETECTORS
WIRES, RPC, MPGD

57 PAPERS



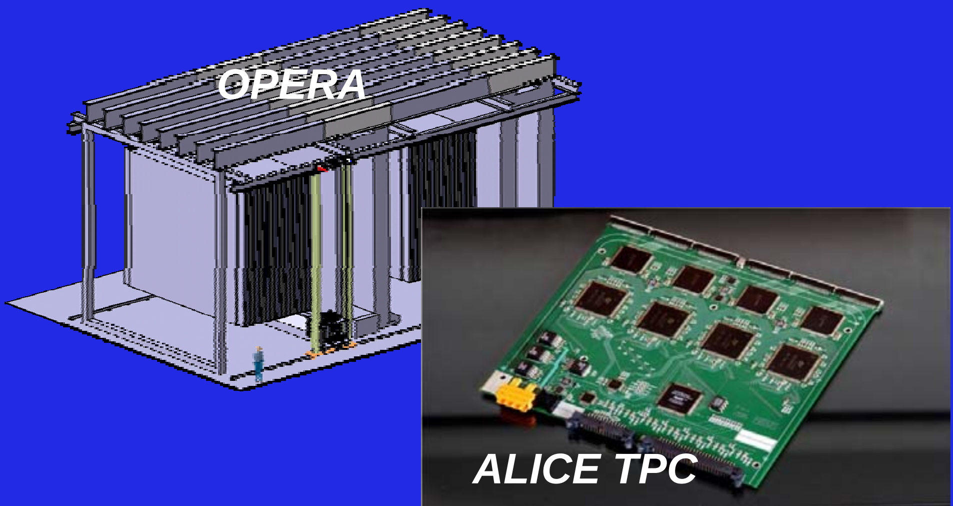
SOLID STATE
PIXELS, STRIPS…

37 PAPERS



PHOTON DETECTION
SCINTILLATORS, SILICON PM,
HYBRID PHOTODIODES, ….

37 PAPERS



OTHERS
SYSTEMS, ELECTRONICS, ….

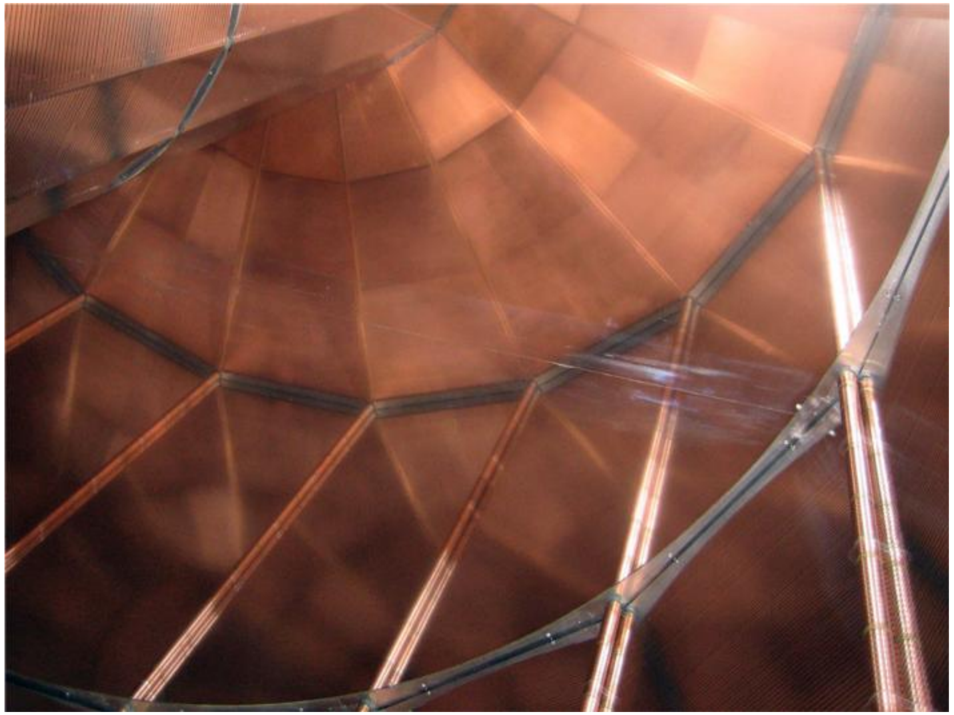
28 PAPERS

+ A FEW EXOTICS

TOTAL ~ 160 CONTRIBUTIONS!

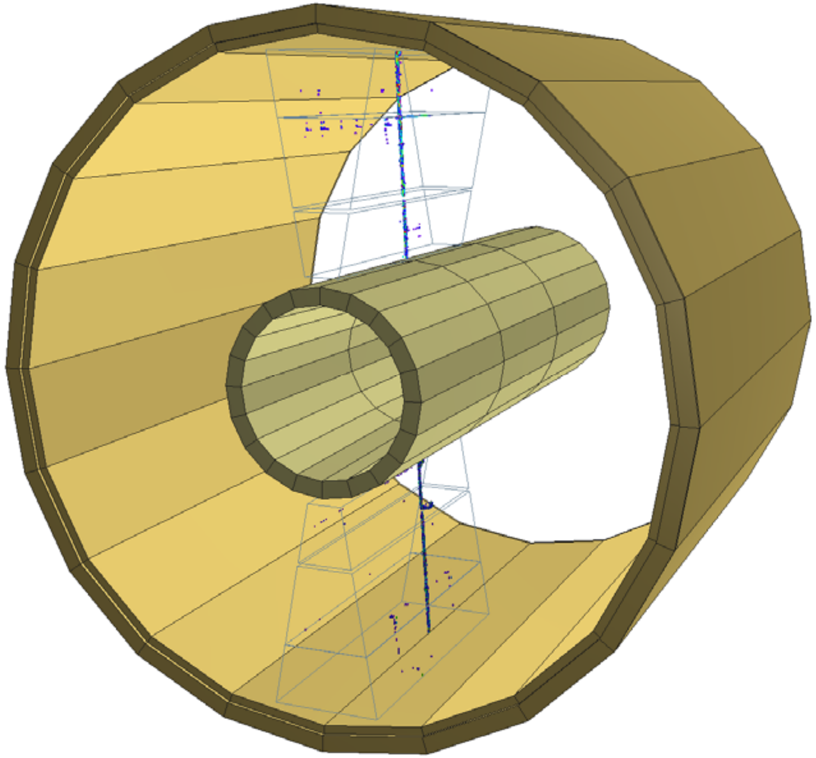
"CLASSIC" GASEOUS DETECTORS

ALICE TPC (U. FRANKENFELD)



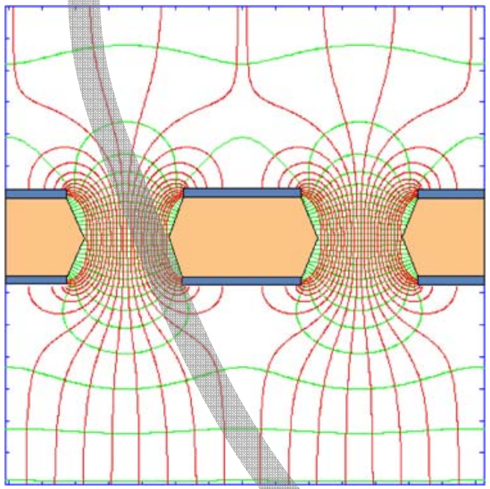
~ 100 m^3 ~0.5 MPADS

FIRST COSMIC EVENT:

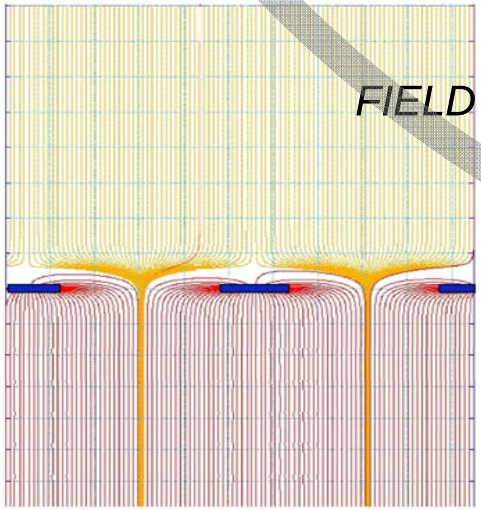


NEW DEVELOPMENTS WITH MICRO-PATTERN GAS DETECTORS (MPGD)

GAS ELECTRON MULTIPLIER (GEM):



MICROMEGAS:



MAIN PERFORMANCES:
- FLEXIBLE READOUT PATTERN
- SPACE ACCURACY ~ 50 µm (5 µm)
- RATE CAPABILITY > 1 MHz/mm^2
- TIME RESOLUTION ~ 5 ns (1 ns)
- TWO-TRACK RESOLUTION ~ 1 mm
- LARGE AREAS: 2000 cm^2 (1 m^2)
- RAD HARD (?)
- FREEDOM OF SHAPE
- NON-PLANAR GEOMETRY
- LOW COST

FIELD GRADIENT LATTICE DETECTOR (FGLD)

MICRO-HOLE AND STRIPS (MHSP)

RESISTIVE ELECTRODE THICK GEM (RETG)

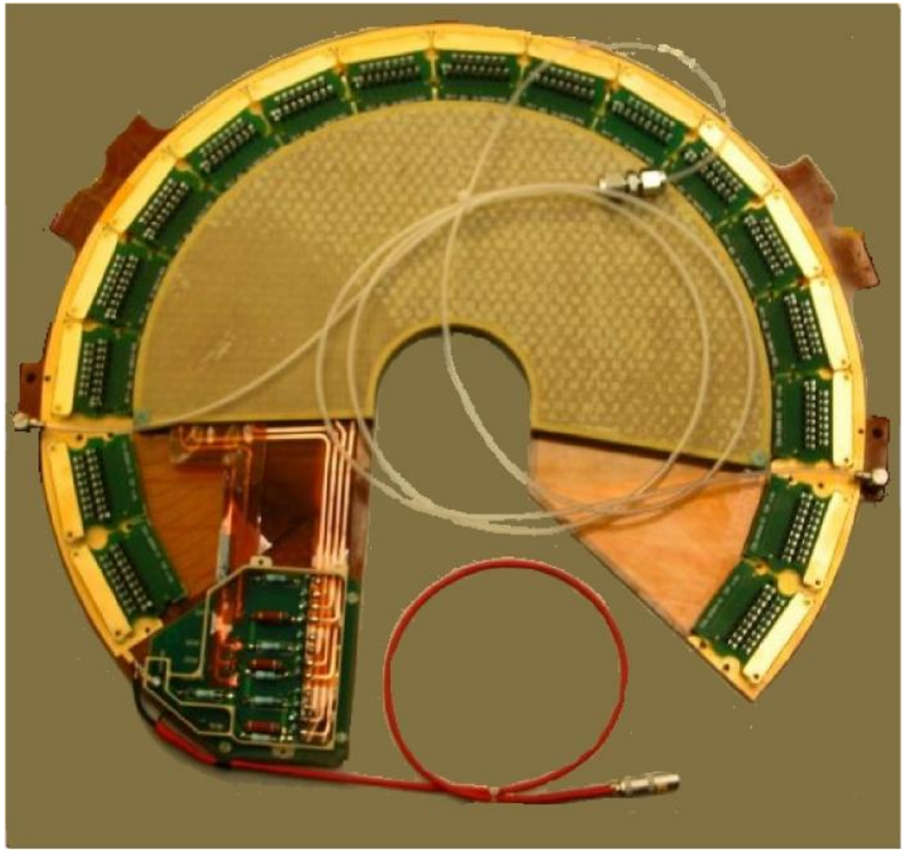
MICRO-PIXEL CHAMBER (µ-PIC)

PHOTON-ASSISTED CASCADED ELECTRON MULTIPLIERS (PACEM)

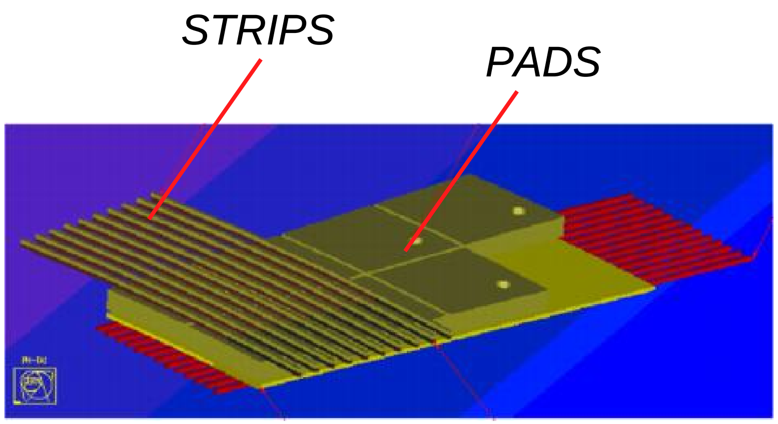
MPGD DETECTORS: FLEXIBILITY IN SHAPE AND READOUT PATTERN

L. ROPELEWSKI

TOTEM HALF-MOON TRIPLE GEM:

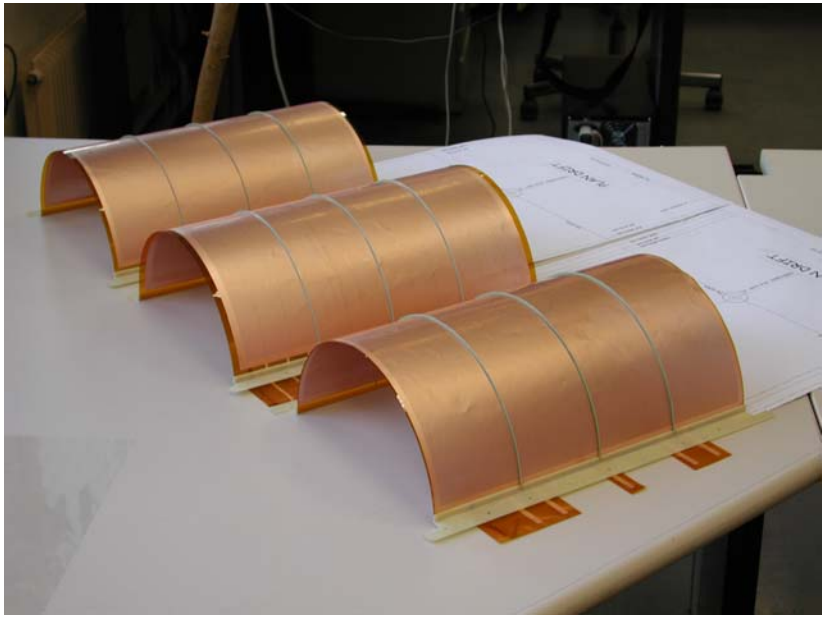


PAD READOUT FOR TRIGGERING AND COARSE AMBIGUITY-FREE COORDINATES
STRIP READOUT FOR ACCURACY

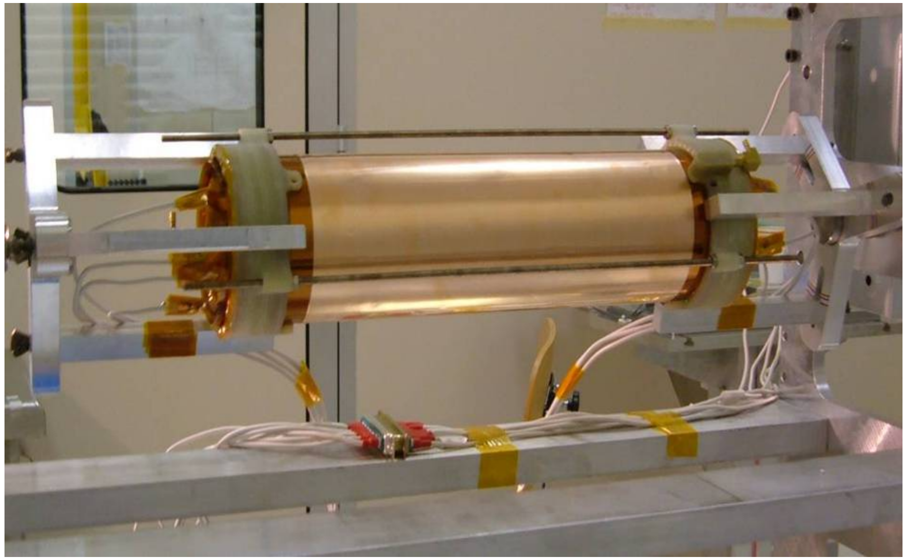


CYLINDRICAL GEM DETECTORS

L. ROPELEWSKI



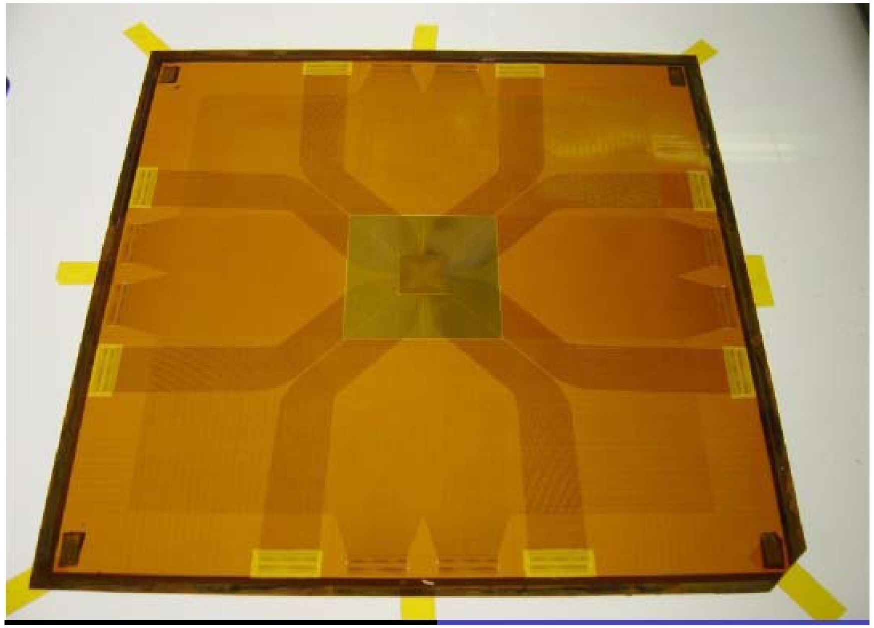
G. BENCIVENNI



LIGHT GEM DETECTOR (0.2% X_0)

F. HAAS

CENTER: 1 mm^2 PIXELS
EDGES: 2D STRIPS



MPGD READOUT OF TIME PROJECTION CHAMBERS
(MAJOR FUTURE PROJECT: ILC DETECTOR)

FAST ELECTRON SIGNAL
$\Delta T \sim 20$ ns (-> ~ 1mm)
NARROW PAD RESPONSE
$\Delta s \sim 1$ mm
VERY GOOD MULTI-TRACK RESOLUTION
$\Delta V \sim 1$ mm^3
STRONG ION FEEDBACK SUPPRESSION
$I^+/I^- < 0.1\%$
NO ExB DISTORTIONS
FREEDOM IN END-CAP DESIGN
ROBUST, RADIATION HARD

PADS INFLATION!

LEGS GEM TPC (G. SMITH)

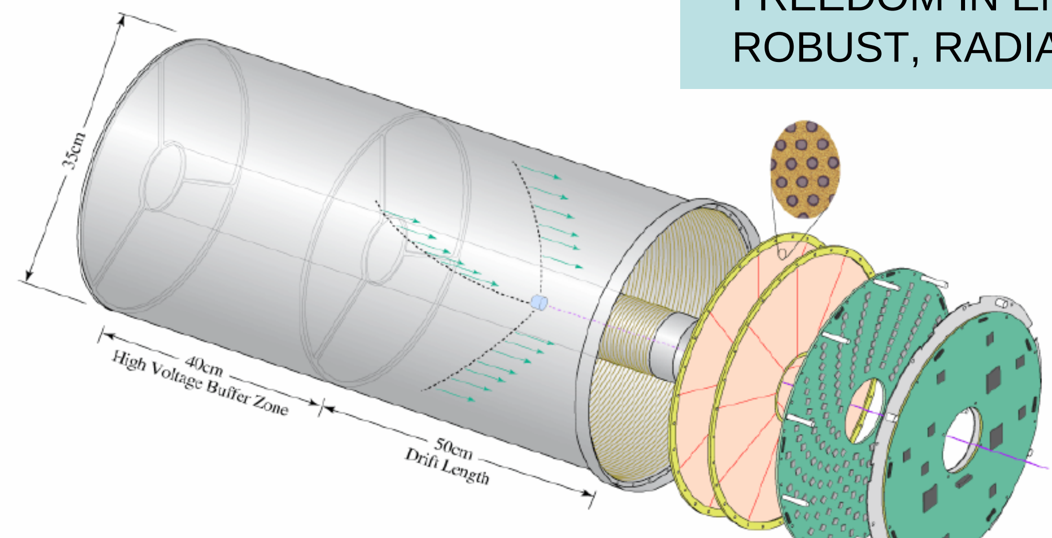


Fig. 1. A schematic illustration of the LEGS TPC.

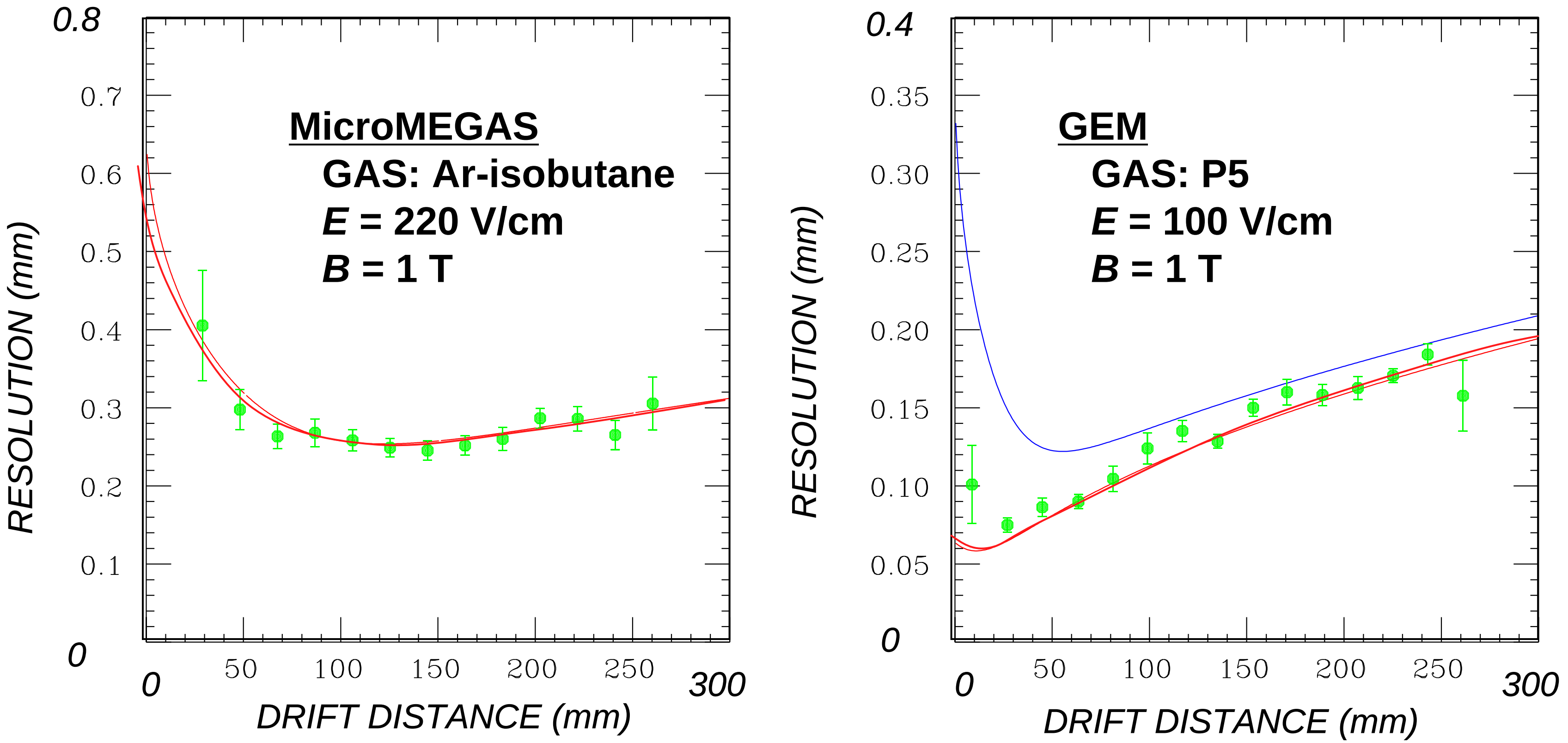
MPGD PAD RESPONSE FUNCTION DILEMMA:

NARROW PRF -> EXCELLENT 2-TRACK RESOLUTION, BUT REQUIRES MCHANNELS!

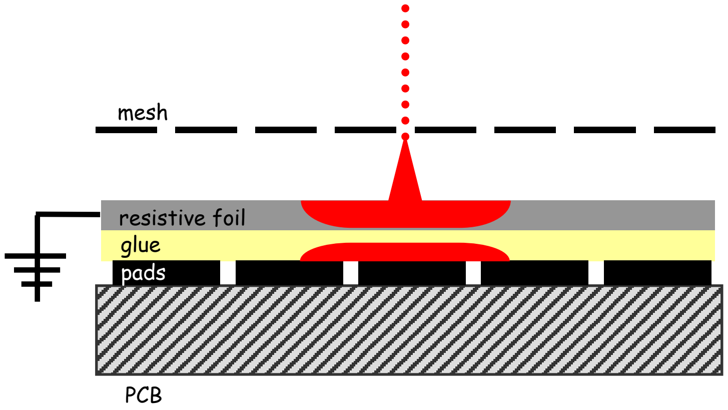
USE OF MULTIGEM HELPS (LARGER CHARGE SPREAD):

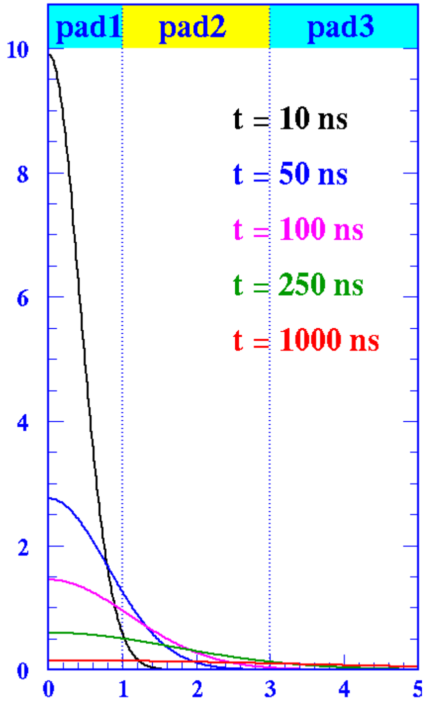
COMPARATIVE STUDIES (MEASUREMENTS AND SIMULATIONS)
M. KOBAYASHI

TYPICAL PAD SIZE ~ 1 mm

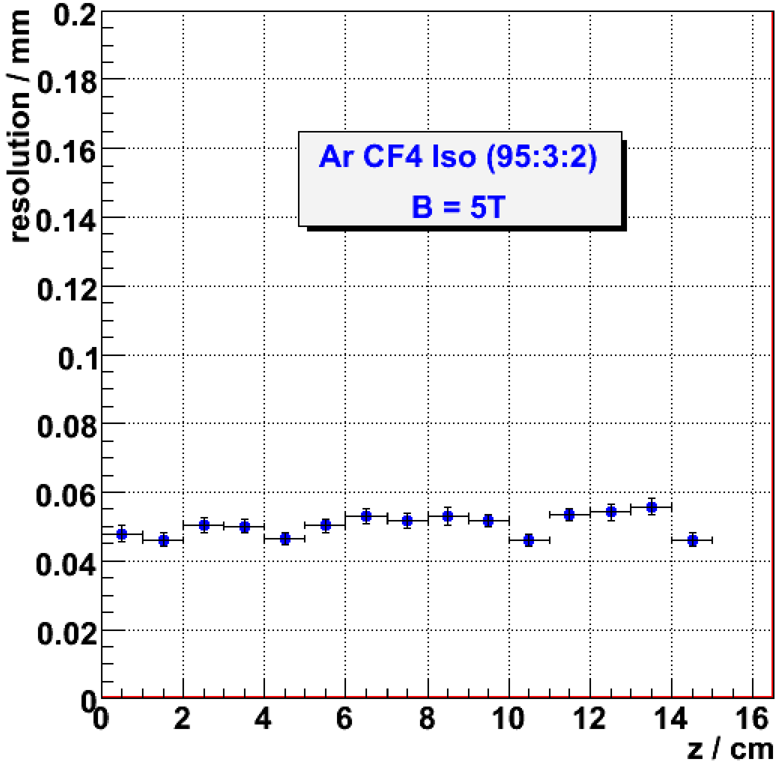


RESISTIVE ANODE READOUT: RC CHARGE SPREAD (D. ATTIE)





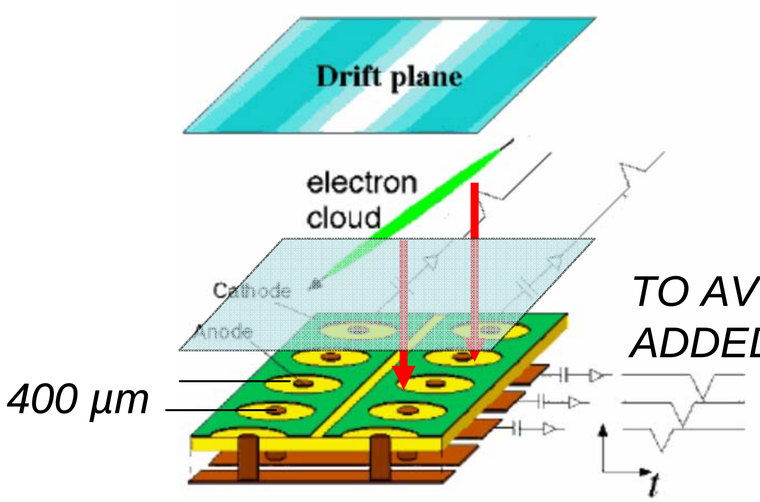
MEASURED RESOLUTION @ 5 TESLA
MICROMEGAS WITH RESISTIVE ANODE



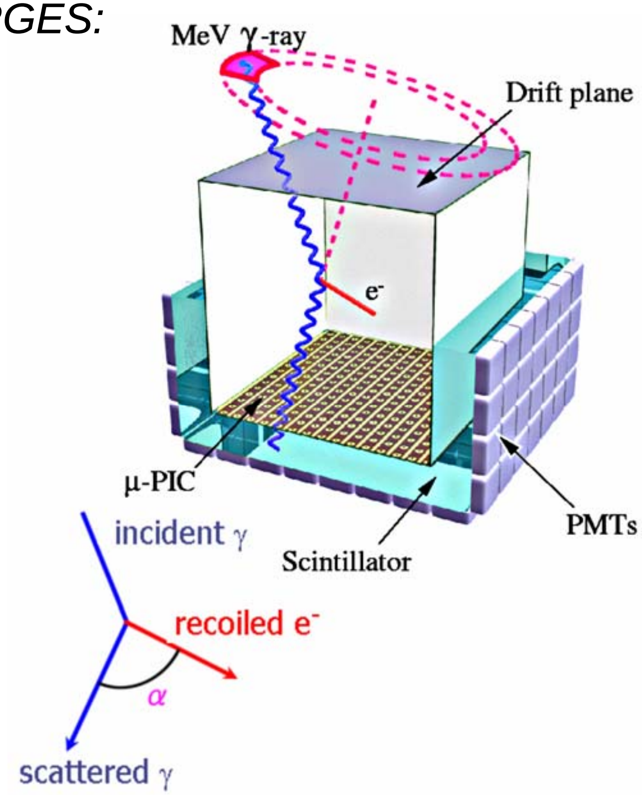
OPEN QUESTIONS:
- UNIFORMITY OF RESISTIVITY
- RATE CAPABILITY
- LOSS IN TWO-TRACK RESOLUTION

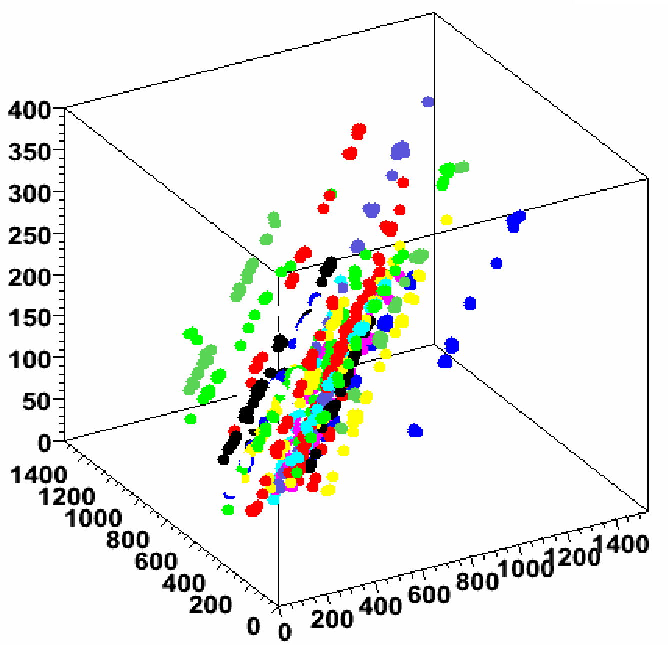
MICRO-PIXEL TPC (K. HATTORI)

COMPTON CAMERA
WITH µTPC + SCINTILLATORS



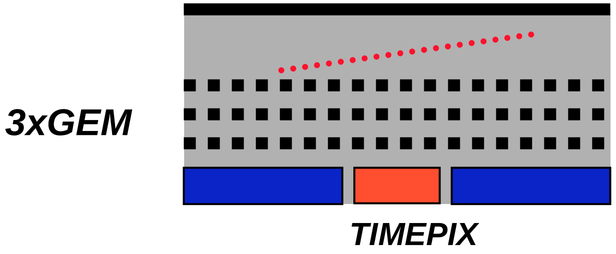
TO AVOID DISCHARGES:
ADDED GEM





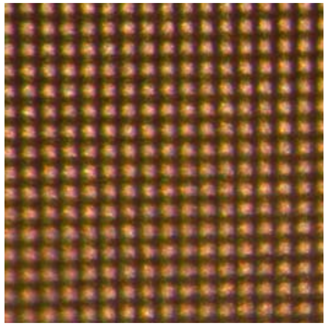
DIRECT CHARGE DETECTION ON SOLID STATE PIXEL ELECTRONICS

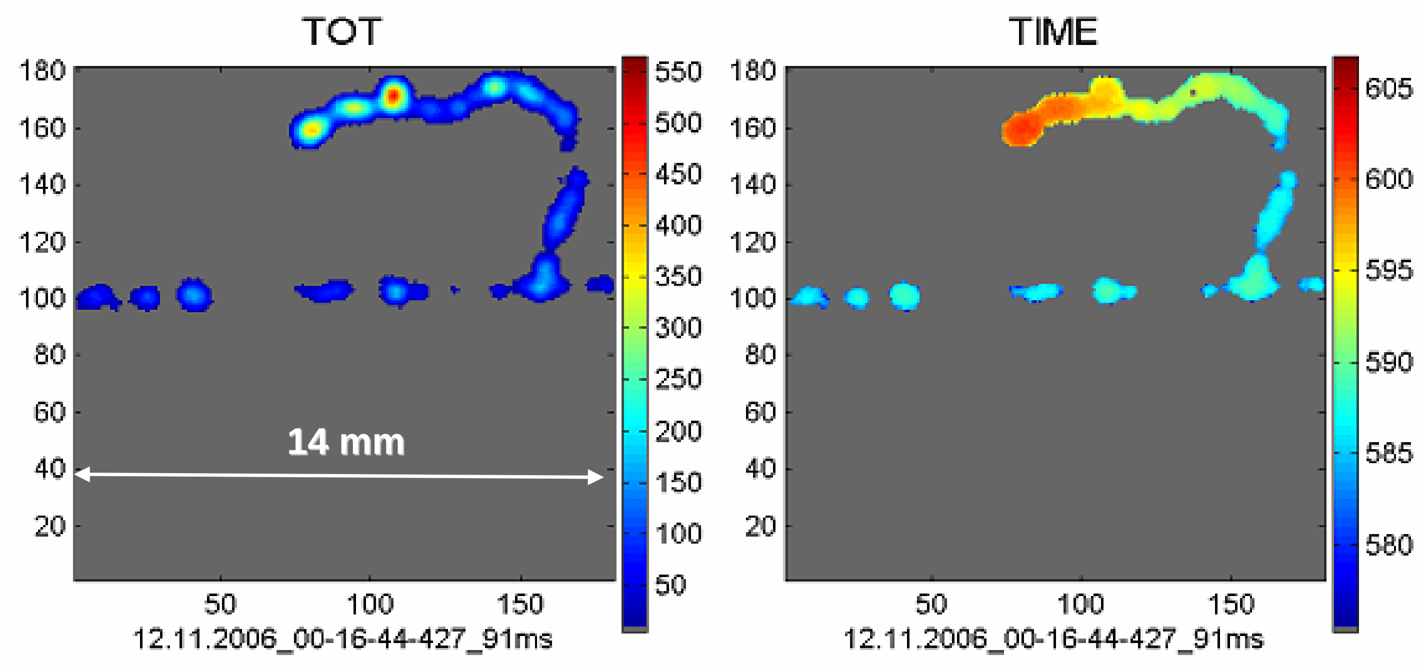
TRIPLE GEM WITH TIMEPIX READOUT (M. TITOV, A. BAMBERGER)



TIMEPIX:
256x256 PIXELS 55 µm x 55 µm

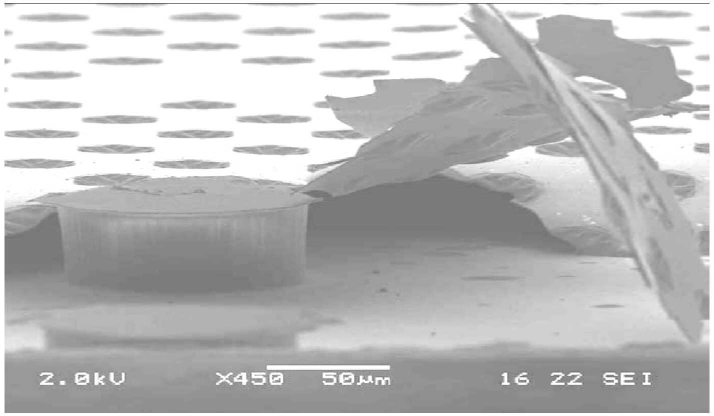
X. LLOPARD

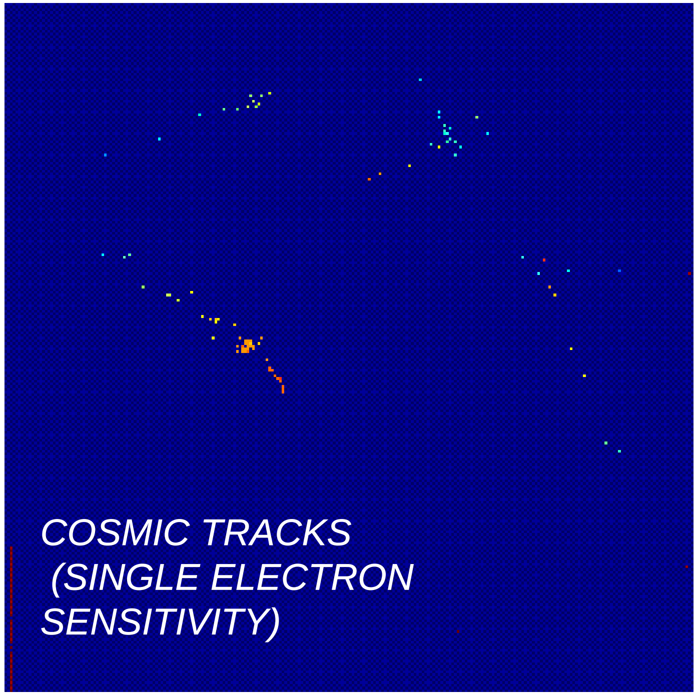




INTEGRATED MPGD AND PIXEL SENSORS I. TIMMERMANS

IN-GRID MICROMEGAS OVER CMOS CHIP:

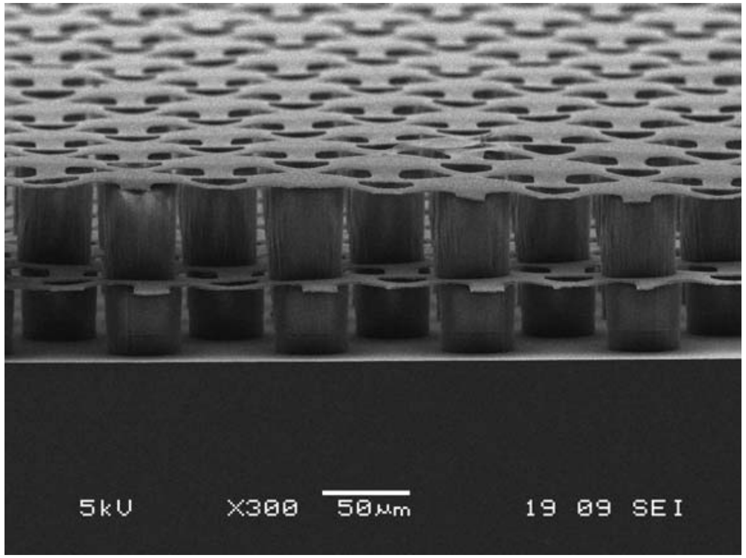




SOLVING SPARK DAMAGE PROBLEMS:

COATING OF THE SENSOR WITH HIGH RESISTIVITY LAYER

MULTI-GRID (A LA GEM):

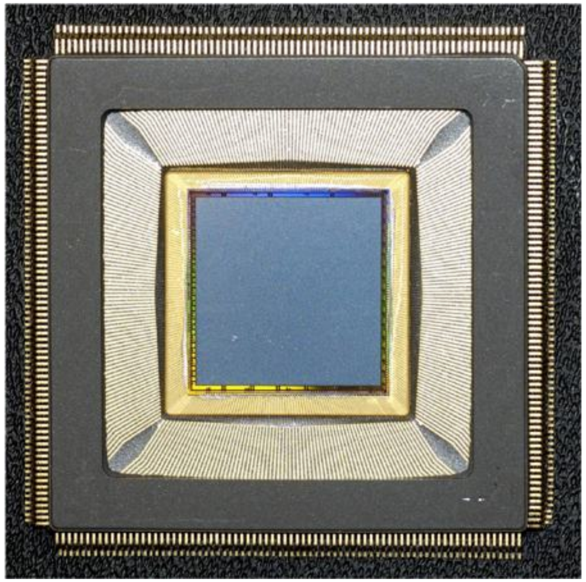


TOWARDS A MICRO-MICRO-PIXEL TPC?

PERSONAL WISHLIST:

~ 500 µm PIXELS MORE APPROPRIATE TO MATCH ELECTRON & AVALANCHE SPREAD!

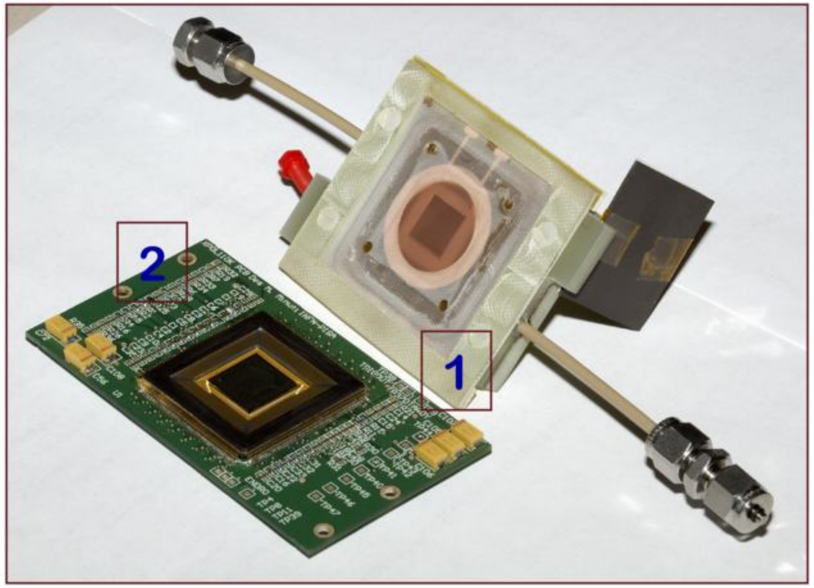
ULTIMATE RESOLUTION OF MPGD+PIXEL READOUT (R. BELLAZZINI)

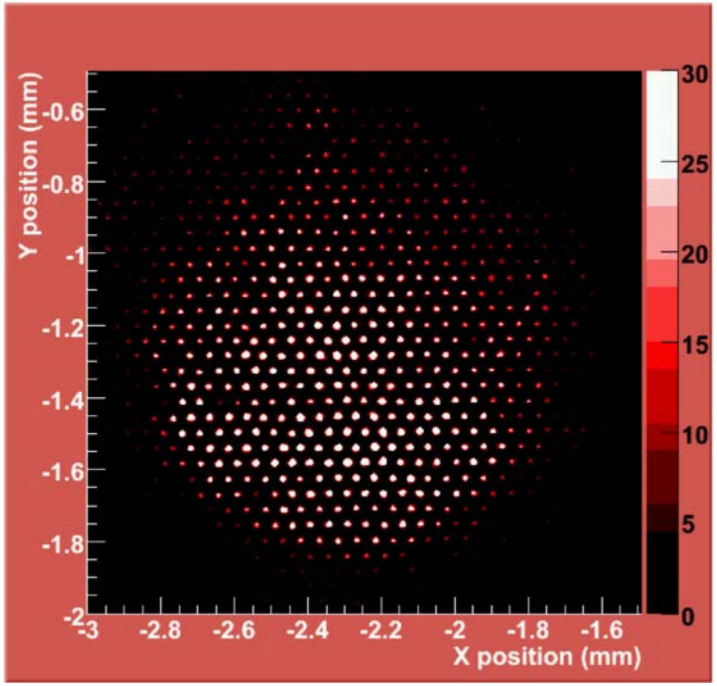


~ 100 kPixels
15x15 mm^2 ACTIVE (470 PIXELS/ mm^2)
CLUSTERED READOUT
50 μm PITCH GEM

GEM SELF-PORTRAIT ON UV LIGHT CsI PHOTOCATODE:

INTRINSIC RESOLUTION ~ 4μm rms





MPGD FOR FUTURE ACCELERATORS: WHAT'S MISSING?

IMPROVE QUALITY CONTROL
FIND ALTERNATIVE PRODUCERS
REDUCE X/X_0
CONFIRM RADIATION TOLERANCE
EXPOSURE TO HEAVILY IONIZING RADIATION (DISCHARGES)

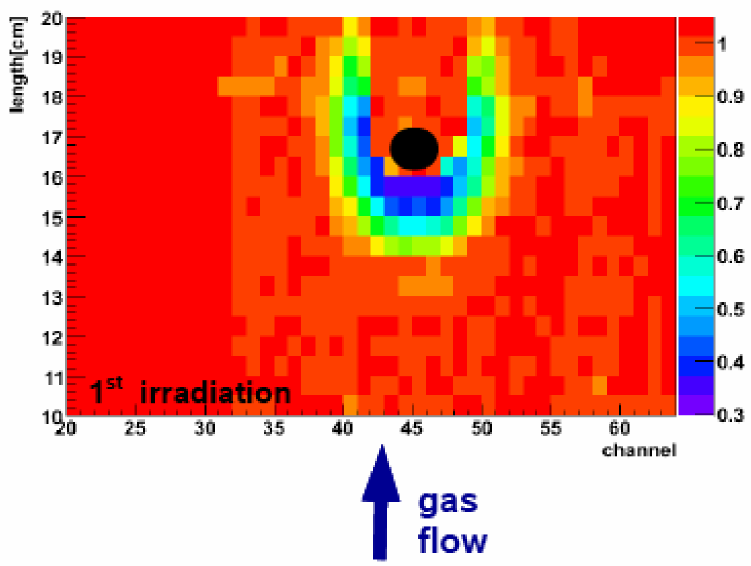
IN ACCELERATED TESTS, NO AGING OBSERVED UP TO ~ 200 mC/mm^2 (~$5x10^{12}$ $MIPS/mm^2$)
MANY YEARS OF STABLE OPERATION IN COMPASS (GEMS AND MICROMEGAS)

AGING MEASUREMENTS STILL CAN RESERVE SURPRISES

T. HAAS (DRIFT TUBES FOR LHCb OUTER TRACKER)

NO AGING IN LONG-TERM, HIGH RATE EXPOSURES

AGING OBSERVED WITH LOW-RATE ^{55}Fe SOURCE!



AGING OF MWPC "DISCOVERED" IN THE 70es
… 40 YEARS LATER STILL A MISTERY!

SOLID STATE DETECTORS

RADIATION TOLERANCE: THE SLHC CHALLENGE (P. COLLINS)

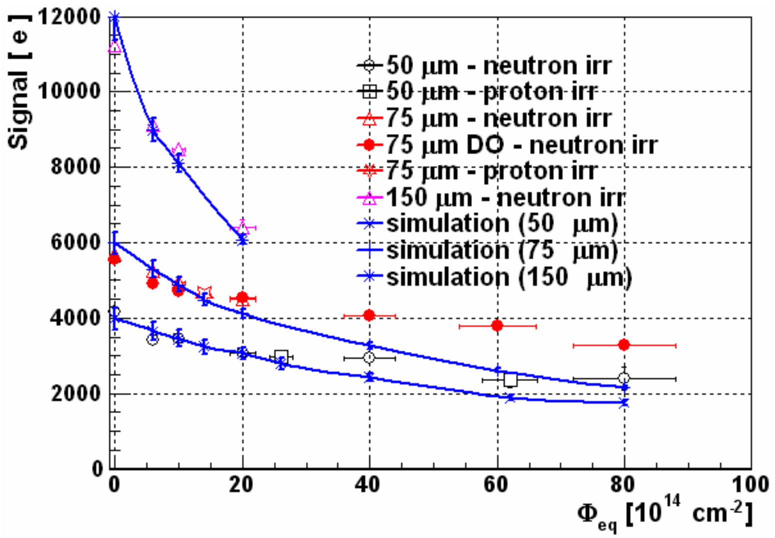
CONTINUING PROGRESS:

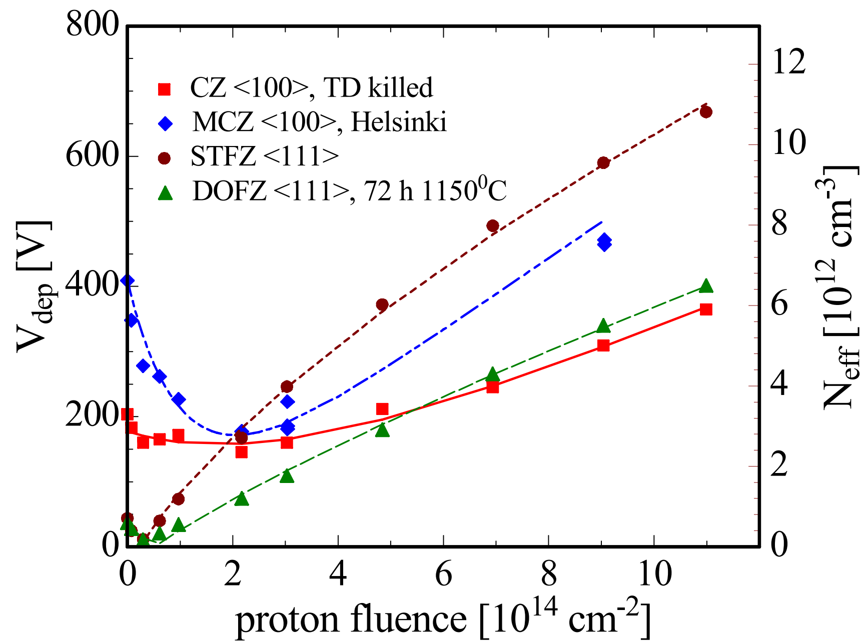
- *UNDERSTANDING RADIATION DAMAGE PROCESSES*
- *IMPROVE INTRINSIC MATERIAL TOLERANCE*
- *NEW DESIGNS*

OXYGENATED SILICON (R. BATES - RD50)

CZOCHRALSKI (CZ), MAGNETIC CZ

EPITAXIAL AND THIN EPITAXIAL

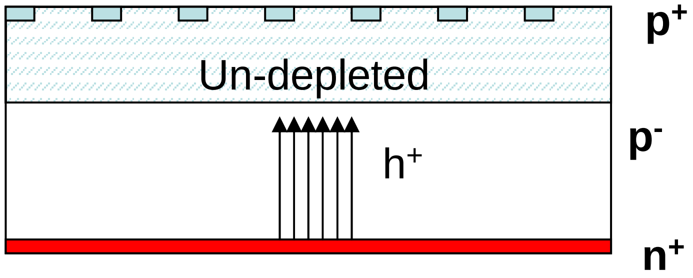




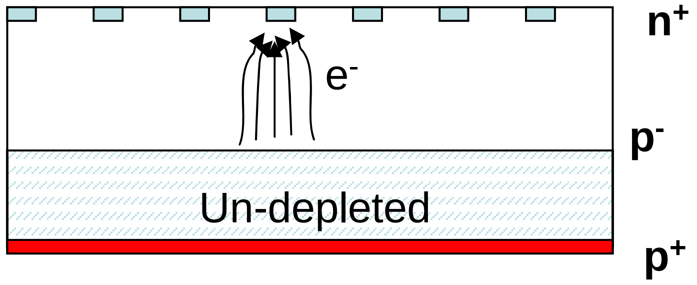
AFTER TYPE INVERSION, n-on-n BECOMES p-on-n. WHY NOT START WITH p-TYPE?

R. BATES

- **“Standard” p-on-n after type inversion**

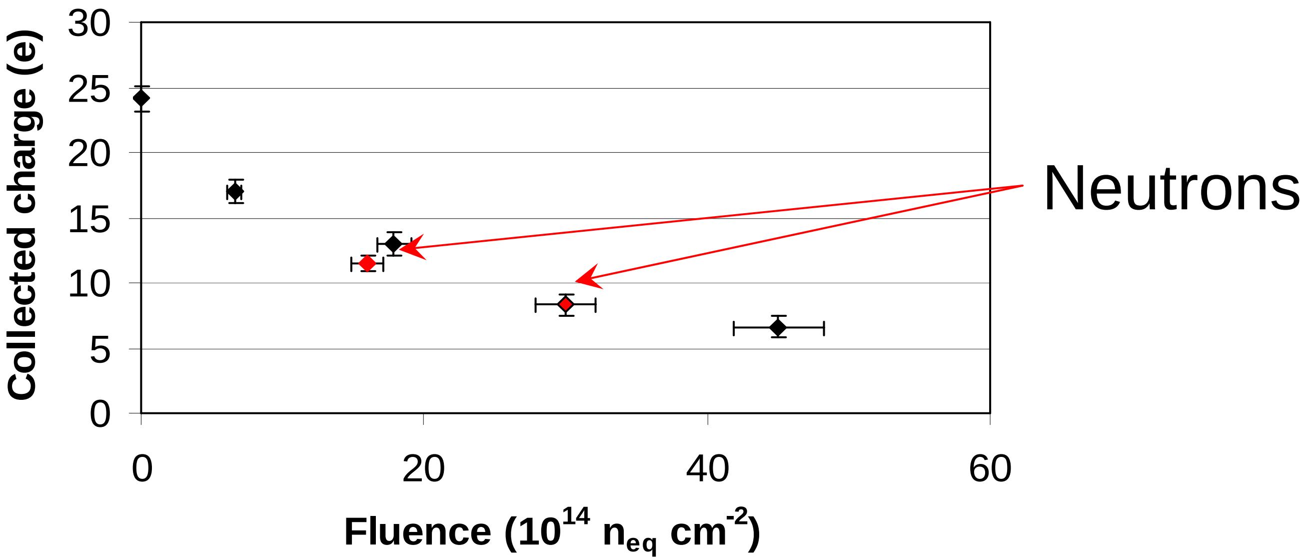


- **“New” n-on-n/n-on-p after type inversion**



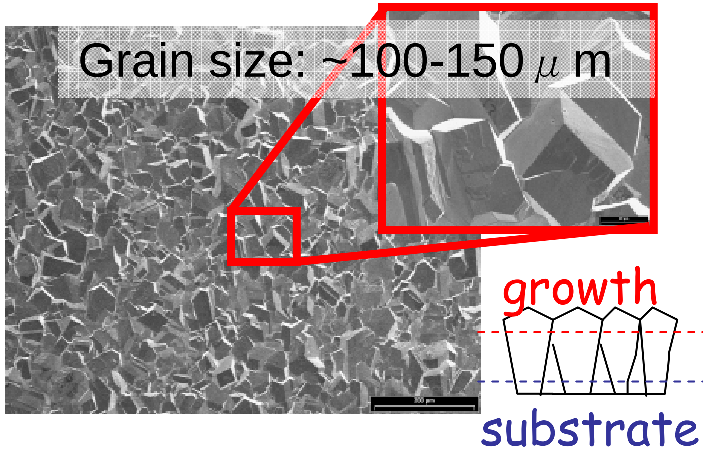
Type inversion turns lightly doped material to “p” type

PRELIMINARY RESULTS OF IRRADIATION:

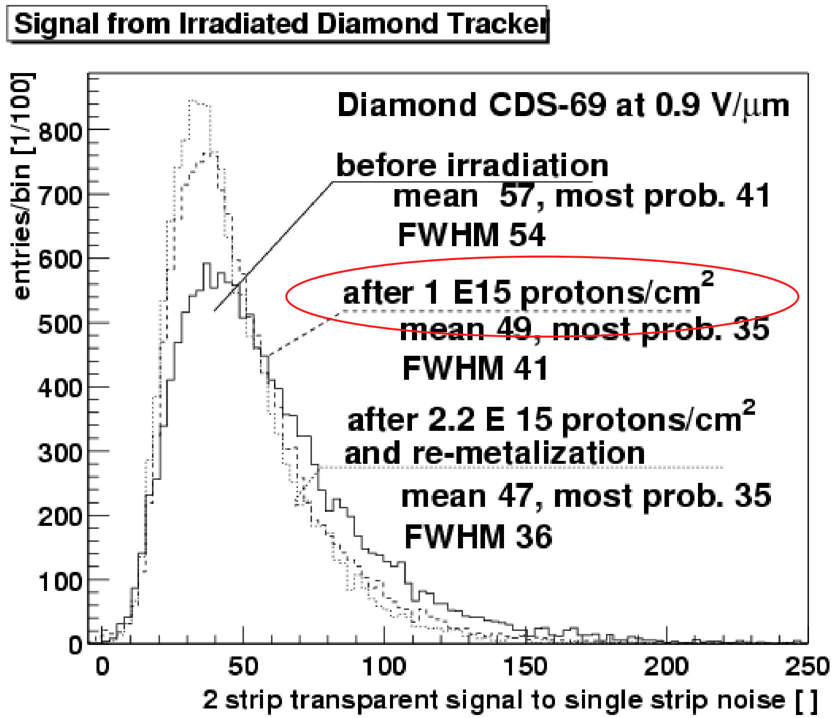


NEW MATERIALS: DIAMOND

Polycrystalline Diamonds traditionally grown by CVD



RADIATION HARDNESS:



SINGLE CRYSTAL DIAMOND DETECTORS 14x14 mm^2 HAVE BEEN MADE

VERY PROMISING, BUT:

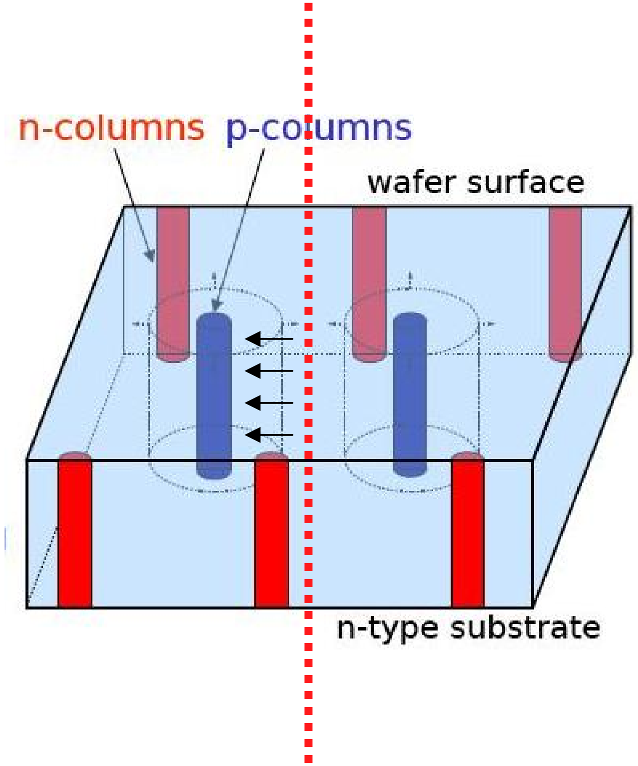
- HIGHER IONIZATION ENERGY (LOWER SIGNALS)
- CVD DEFECTS
- HIGH COST

IMPROVED GEOMETRY

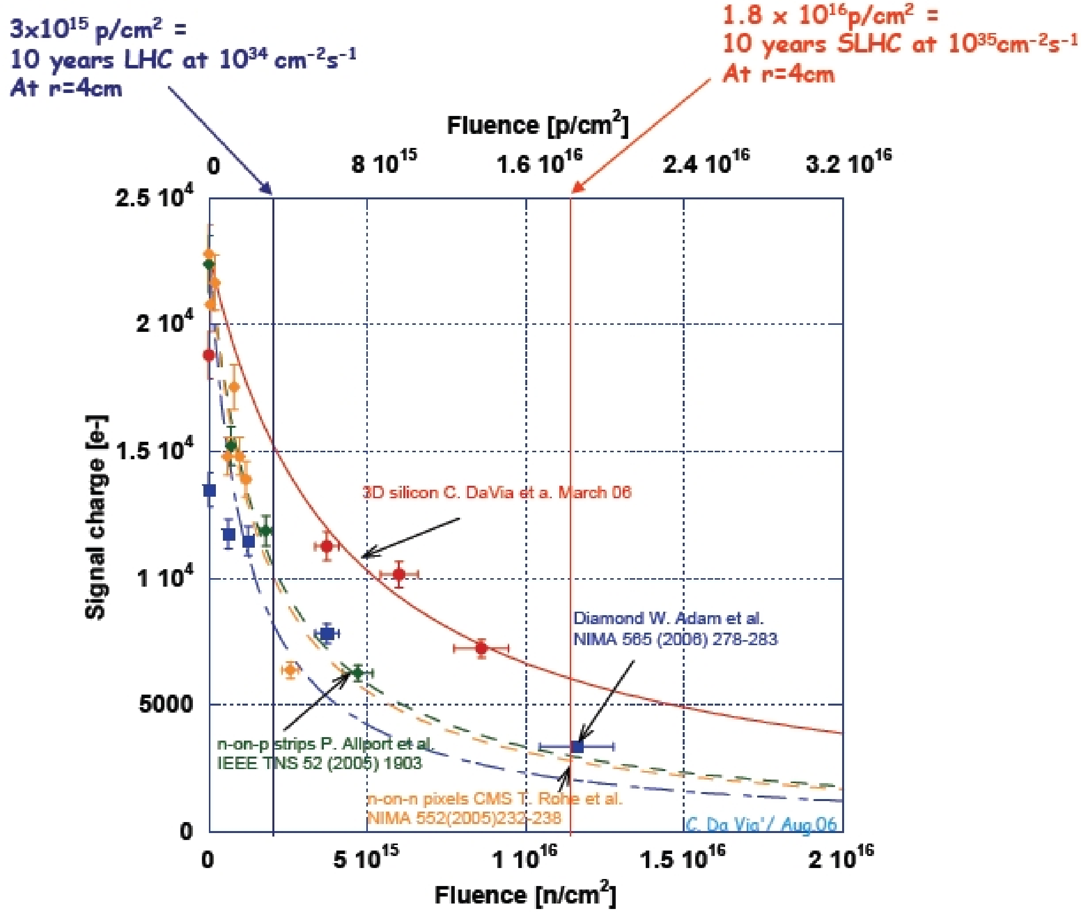
RADIATION DAMAGE REDUCES THE EFFECTIVE THICKNESS OF THE DETECTOR:
MAKE THEM THINNER (PRESERVING EFFICIENCY!)

S. ECKERT

3-D SILICON DETECTORS



RADIATION HARDNESS:

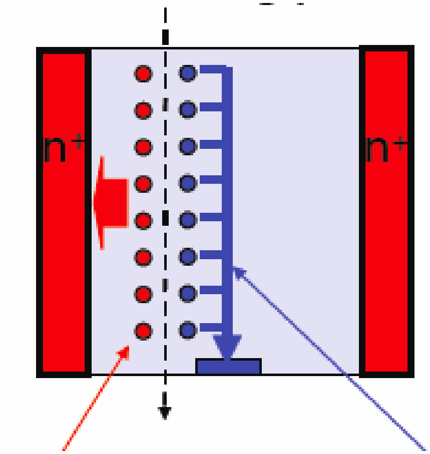


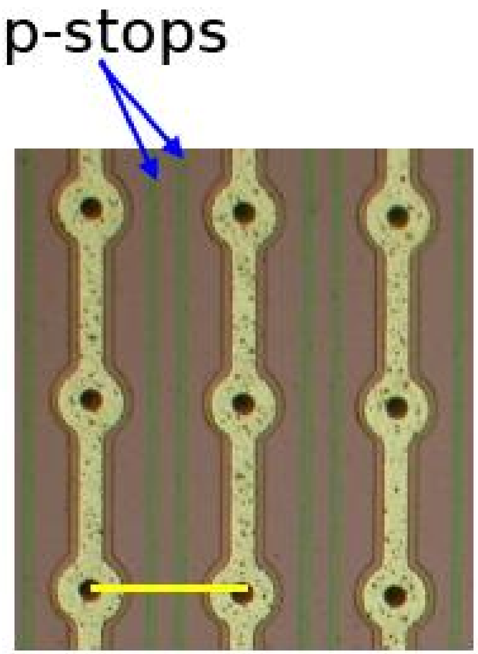
AFTER $5x10^{15}$ n/cm^2 ~ 50% CHARGE LOSS

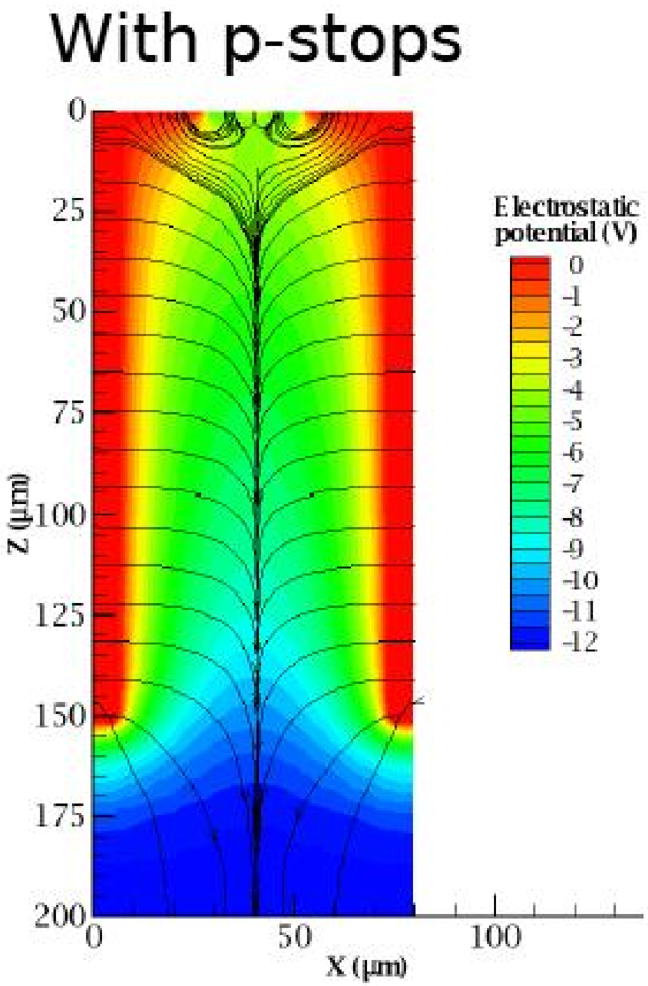
3-D DETECTORS: NEW DESIGNS

S. ECKERT

SINGLE-TYPE COLUMN DESIGN (ITC-irst)



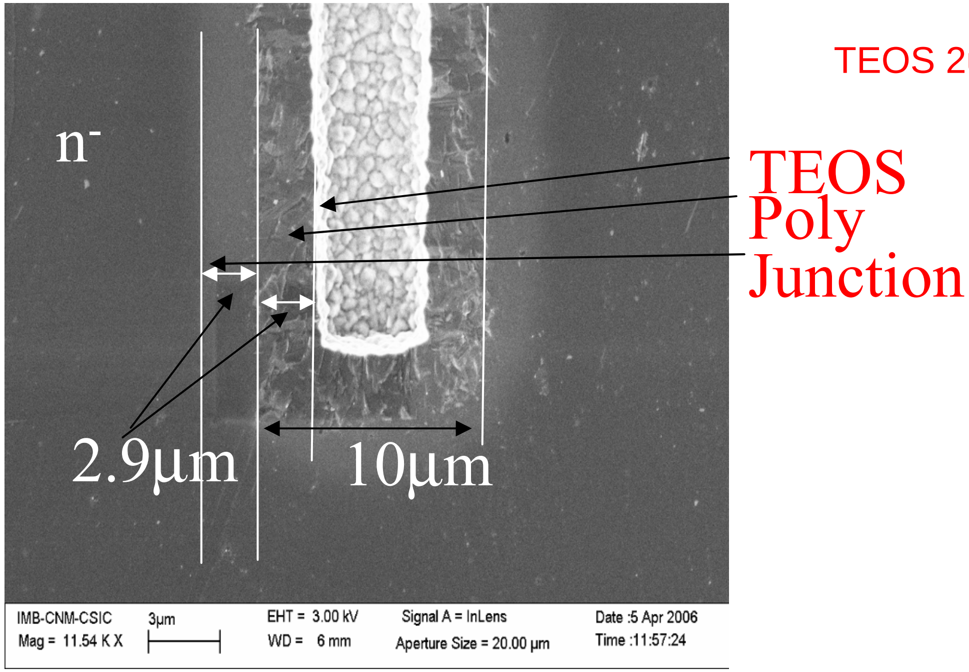


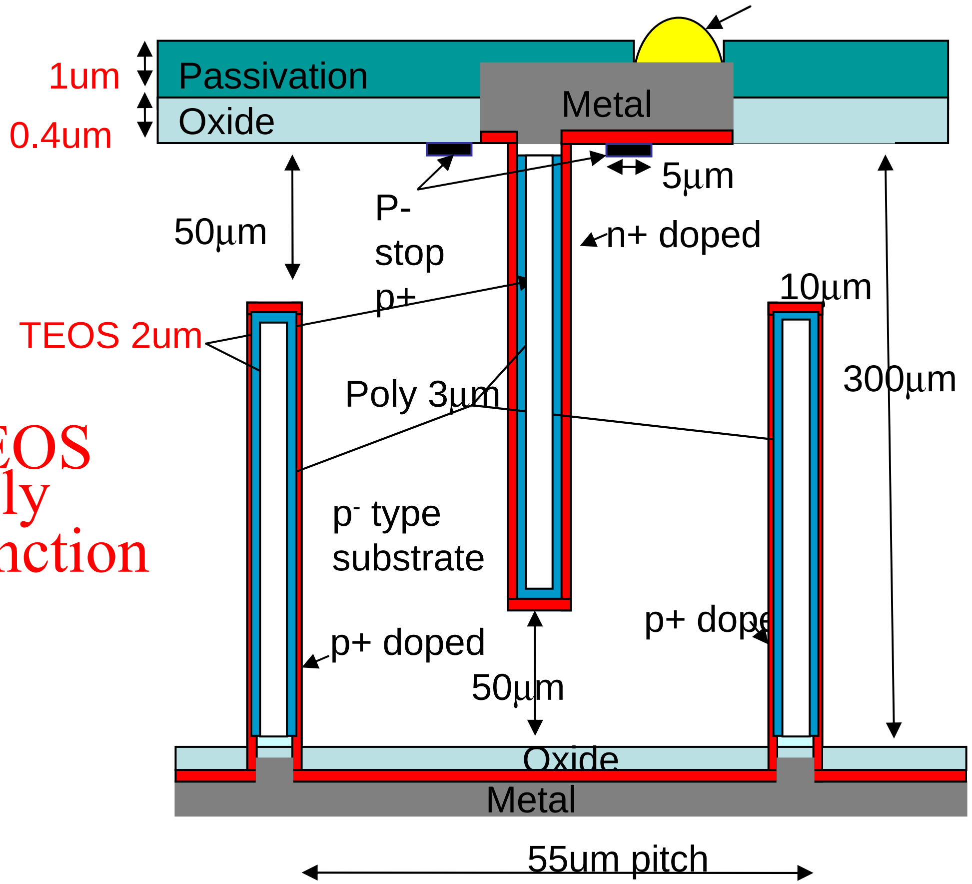


LASER SCAN SYSTEM FOR DEVICE CHARACTERIZATION
LOW FIELD REGIONS (NOT VERY EFFICIENT CHARGE COLLECTION)

DOUBLE-TYPE COLUMN TO REDUCE LOW FIELD REGIONS

S. ECKERT (CNM AND GLASGOW)





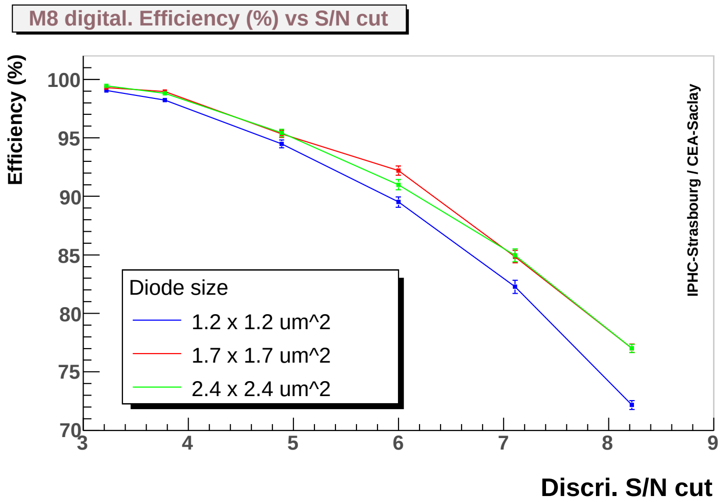
PIXEL DETECTORS

MAPS: MONOLITIC INTEGRATION OF SENSOR AND READOUT ELECTRONICS

CMOS SENSORS DEVELOPMENTS
(W. DULINSKI)

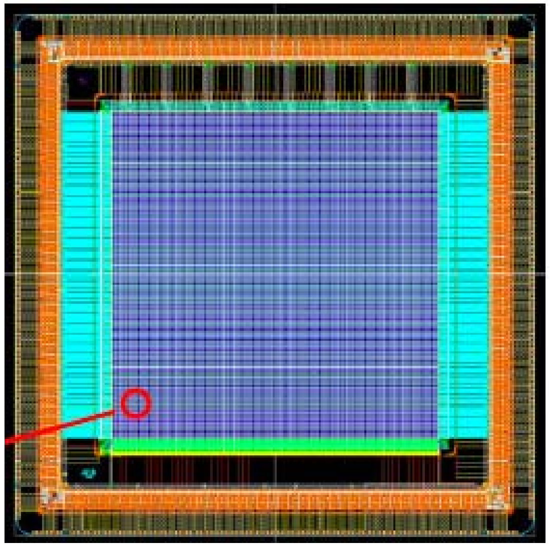
MIMOSA8
25x25 µm^2 PIXELS
SPATIAL RESOLUTION ~ 7 µm

EFFICIENCY IN TEST BEAM:



SILICON-ON-INSULATOR (T. TSUBOYAMA)

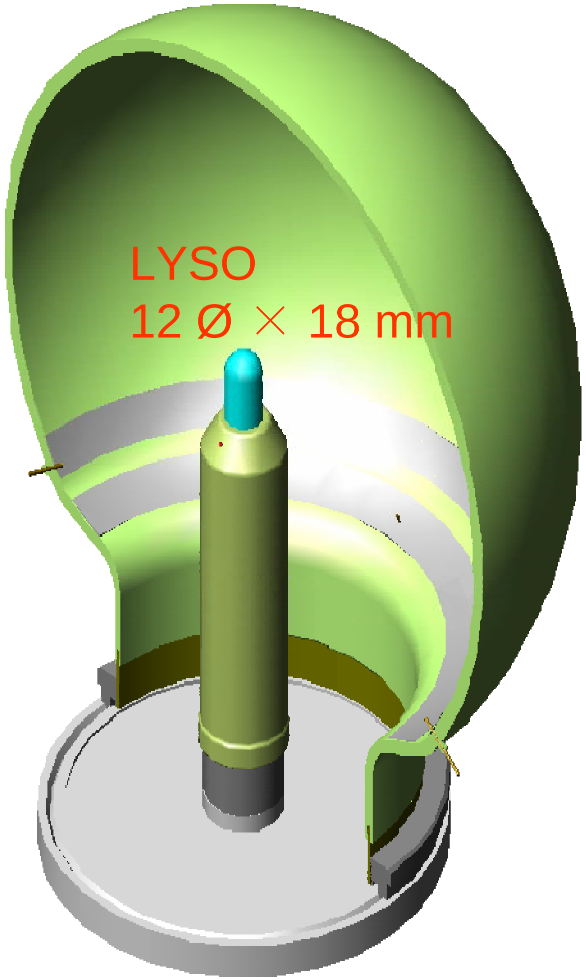
128x128 PIXELS, 50x50 µm^2



VERY GOOD ACCURACY AND MULTI-PARTICLE RESOLUTION
INTEGRATED ELECTRONICS (LOW MASS)
POOR SIGNAL/NOISE
RELATIVELY SLOW READOUT
NOT VERY RAD HARD (~ 10^{12} n/cm^2)
SUITED FOR HIGH MULTIPLICITY, MODERATE RATES (ILC)

NEW “CLASSIC” PHOTON DETECTORS

C. JORAM
HIBRID PHOTOMULTIPLIERS: X-HPD
(CERN-PHOTONIS)

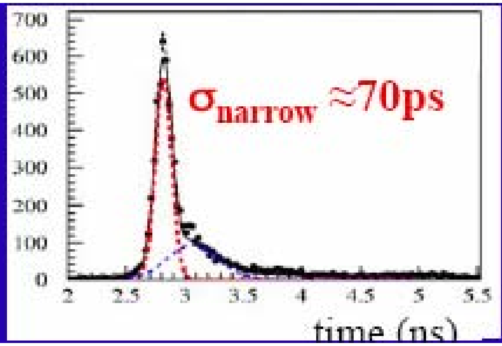


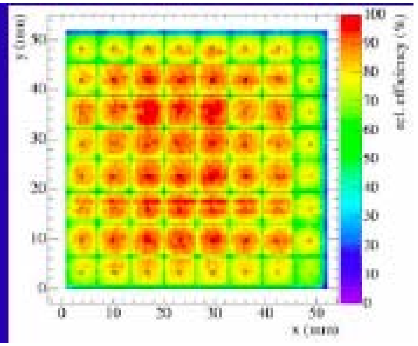
P. KRIZAN
GaAs PHOTOCATHODE PM (HAMAMATSU)

REDUCED CHROMATIC ABERRATION FOR RICH COUNTERS

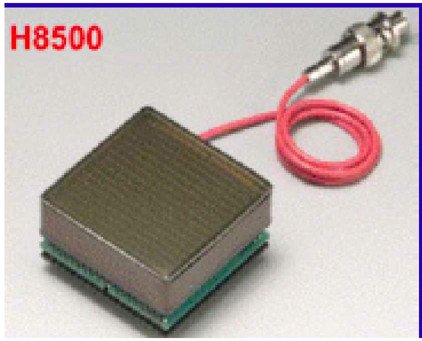
IMPROVED PM RESPONSE AND TIME RESOLUTION (J. VA'VRA)

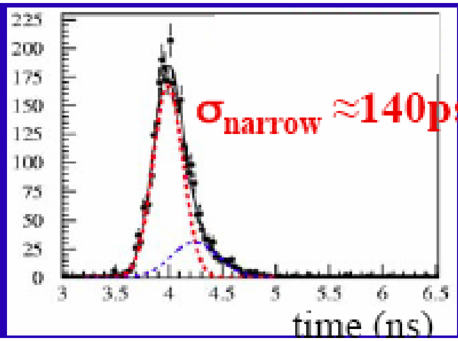
BURLE 85011-501 MCP

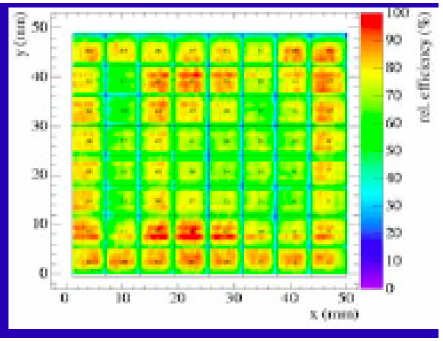




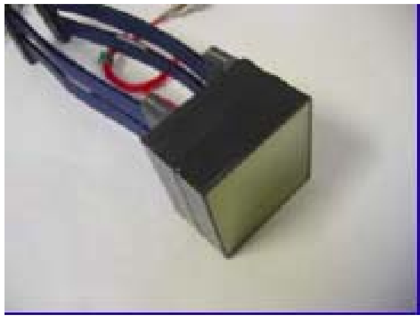
HAMAMATSU H-8500 MaPMT

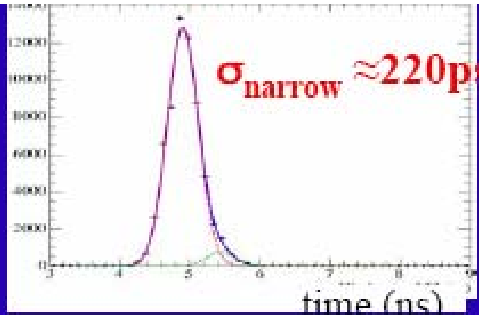


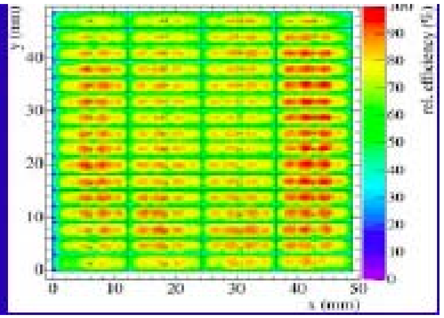




HAMAMATSU H-9500 FLAT PANEL



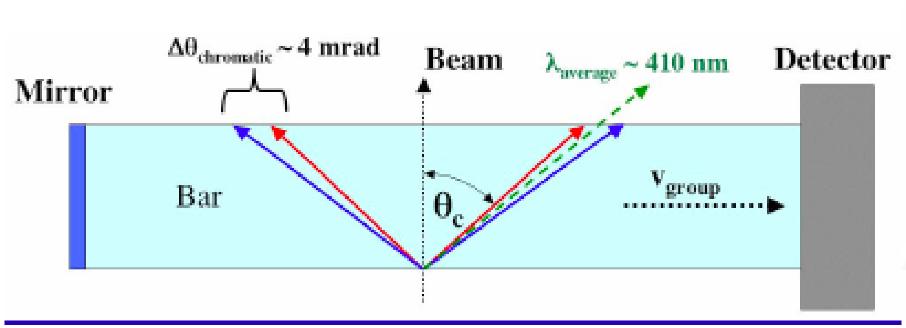


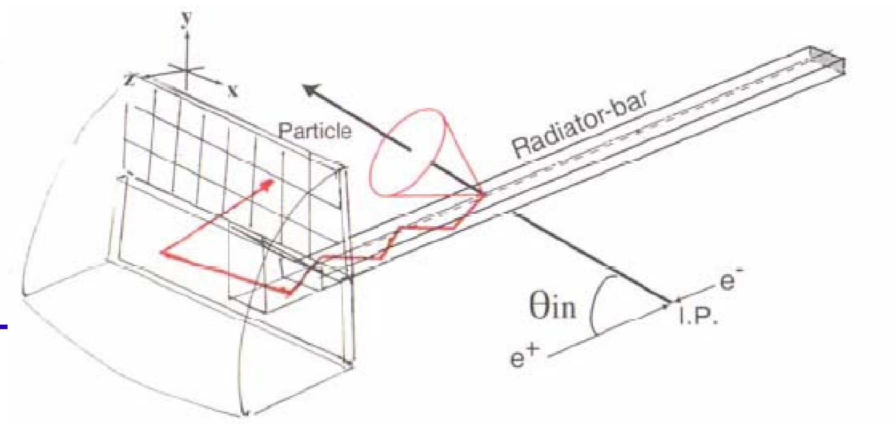


IMPROVING PARTICLE IDENTIFICATION (P. KRIZAN)

PHOTON PROPAGATION TIME IN MEDIUM DEPENDS ON WAVELENGTH:

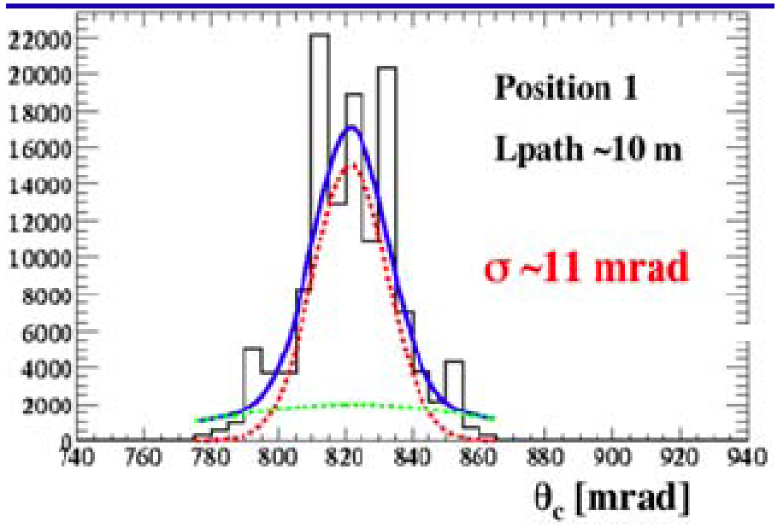
FOCUSING DIRC: RICH WITH CHROMATIC ERROR CORRECTION (J. VA'VRA)

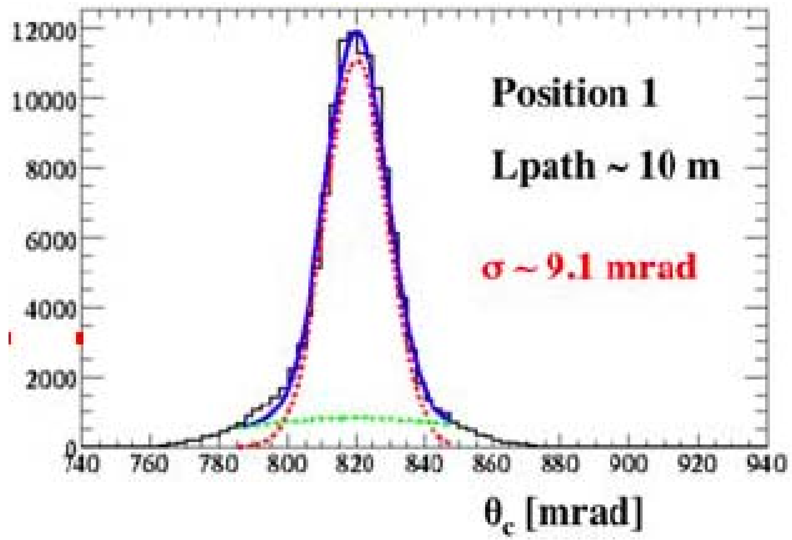




ANGULAR RESOLUTION BEFORE CORRECTION:

AFTER CORRECTION

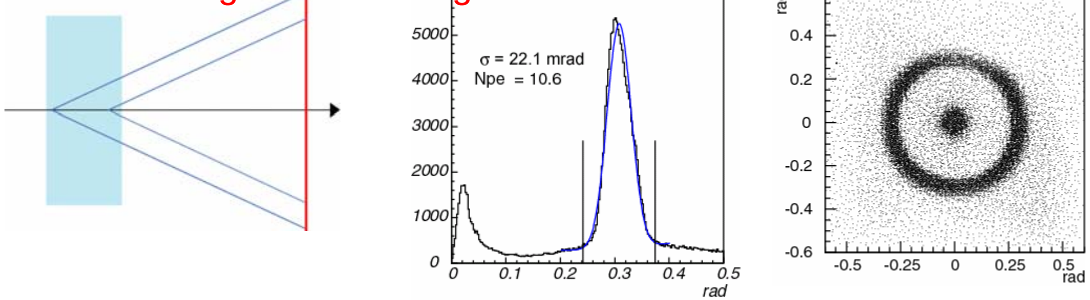




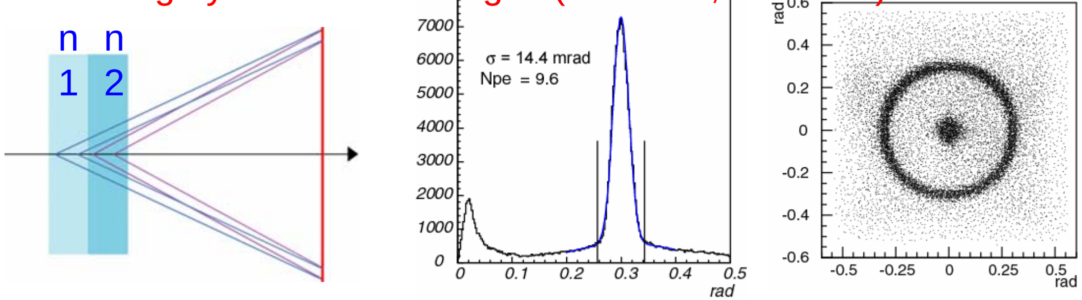
MULTI-LAYER AEROGEL PROXIMITY FOCUSING RICH (I. ADACHI)

TWO AEROGEL SLABS (11x11x2 and 15x15x2 cm^3:

4cm-thick single index aerogel



Focusing by 2cm+2cm aerogel (n1:1.047, n2:1.057)



SOLID STATE PHOTON DETECTORS

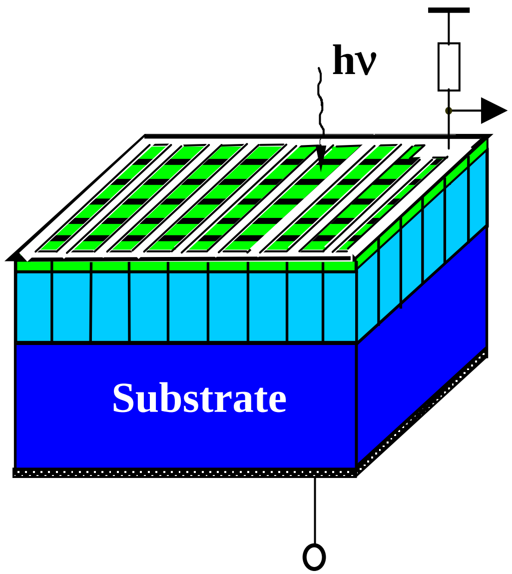
SILICON PHOTODIODE:

WIDE SPECTRAL RANGE, HIGH QUANTUM EFFICIENCY, GAIN 1

AVALANCHE PHOTODIODE: GAIN ~ 100

GEIGER MODE PHOTODIODE: GAIN ~ 10^5 (UNSTABLE, LONG DEAD TIME)

THE SOLUTION: MATRIX OF INDEPENDENT GEIGER PIXELS ARRAY



THE NAME SAGA:
SILICON PHOTOMULTIPLIER (SiPM)
MULTI-PIXEL PHOTON COUNTER (MPPC)
AVALANCHE MICROCHANNEL PHOTODIODE (AMPD)
GEIGER MODE AVALANCHE PHOTODIODES (G-APD)

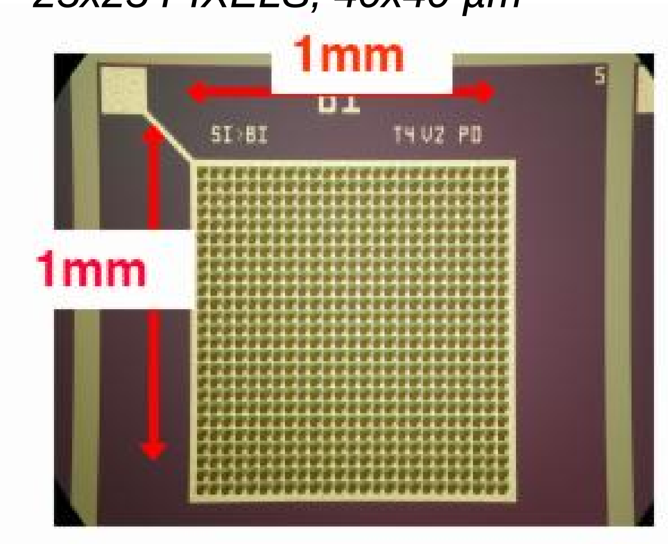
- SINGLE PHOTON SENSITIVITY
- VERY GOOD TIME RESOLUTION: 50-100 ps
- “PROPORTIONAL” TO INPUT SIGNAL
- HIGH Q.E. ~ 80% (POTENTIALLY)
- OPERATION IN HIGH MAGNETIC FIELD
- LOW COST

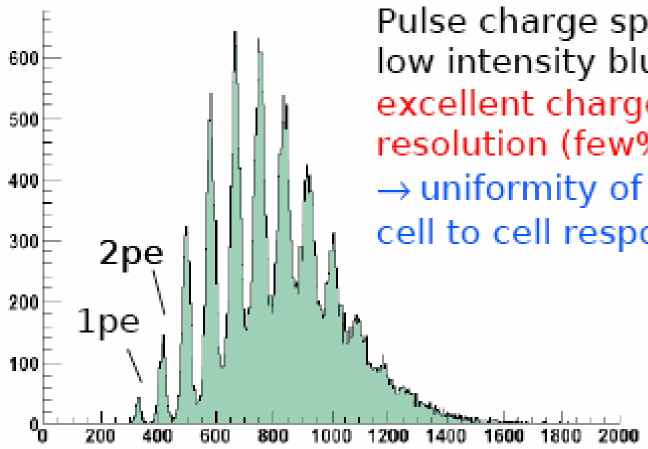
HIGH SINGLE ELECTRON NOISE (100 kHz-1MHz)

SiPM DEVELOPMENT

G. COLLAZUOL (ITC-irst)

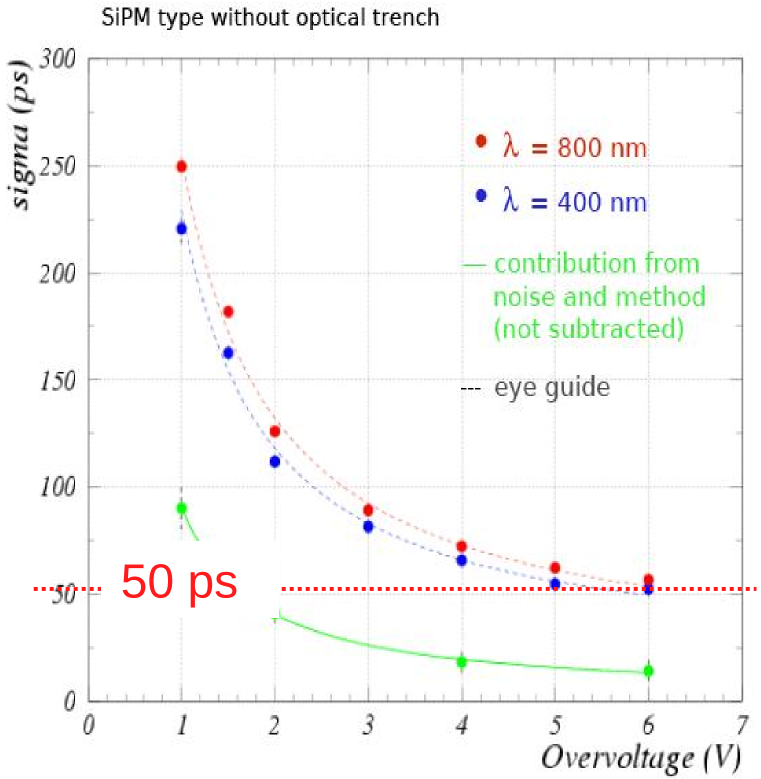
25x25 PIXELS, 40x40 µm





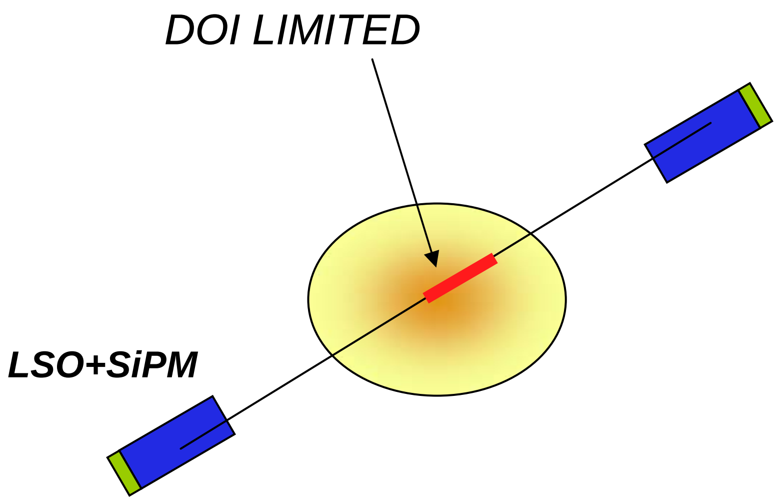
Pulse charge spectrum
low intensity blue LED
excellent charge
resolution (few%)
→ uniformity of
cell to cell response

SINGLE PHOTOELECTRON TIMING USING FEMTO-SECOND LASER PULSES:

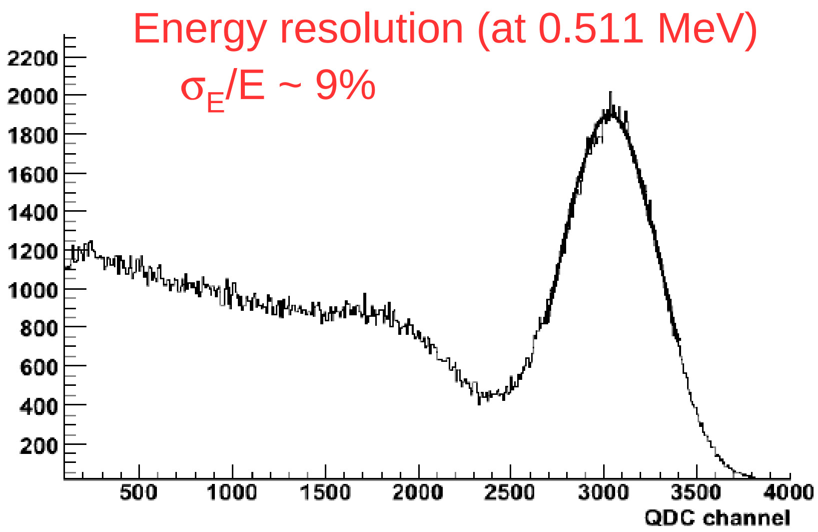


SiPM+SCINTILLATOR: DEPTH OF INTERACTION IN PET SCANNERS

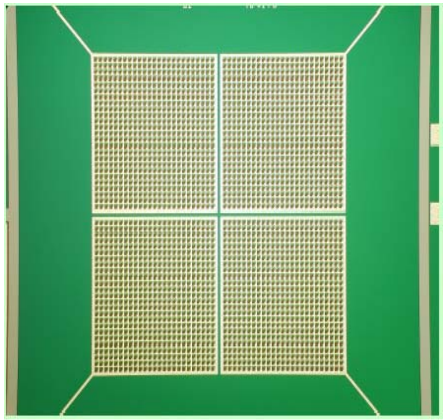
REDUCTION OF NON-CORRELATED BACKGROUND



^{22}Na SPECTRUM WITH 1x1x10 mm^3 LSO READOUT WITH 1x1 mm^2 LSO:



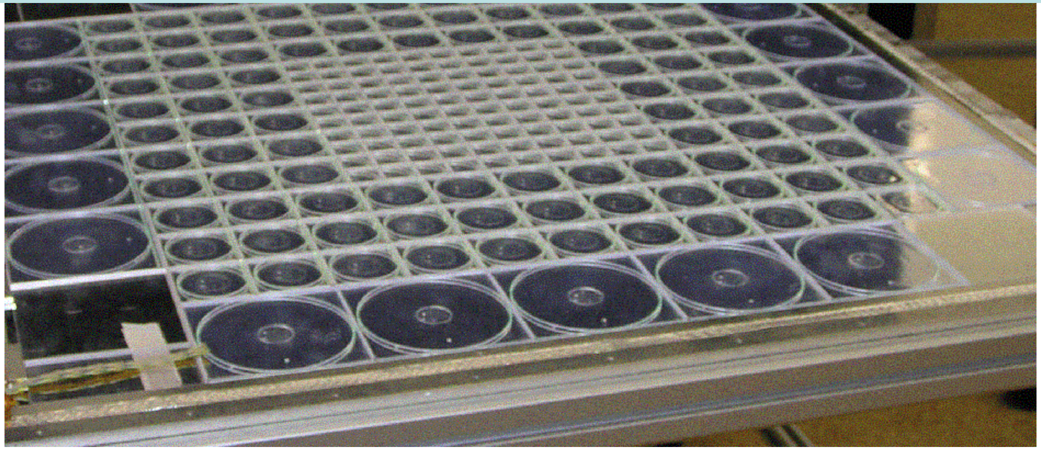
CURRENTLY TESTED:
2x2 SiPM MATRIX



M. DANILOV

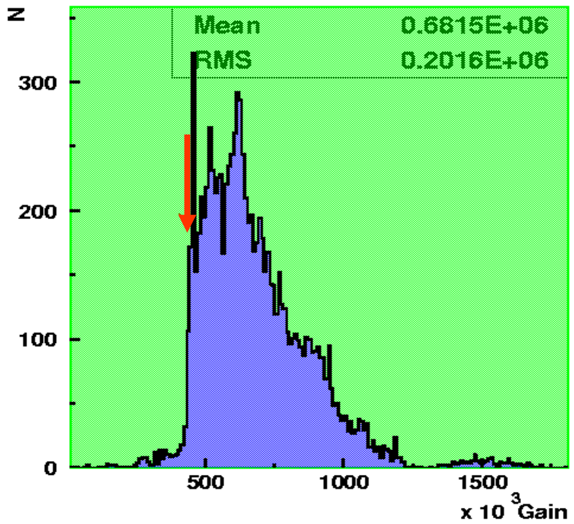
HCAL prototype: 38 planes of scintillating detectors
Light from a tile is read out via WLS fiber and SiPM

PROTOTYPE SCINTILLATOR TILE HADRON CALORIMETER FOR ILC

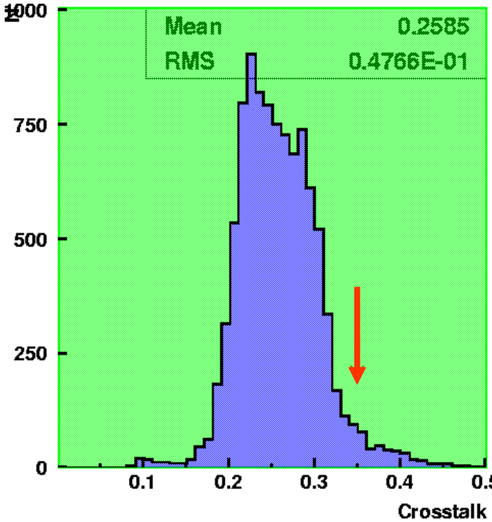


FIRST LARGE SCALE PRODUCTION:

CHARACTERIZATION OF 10,000 SiPM (MEPhI-PULSAR):



GAIN

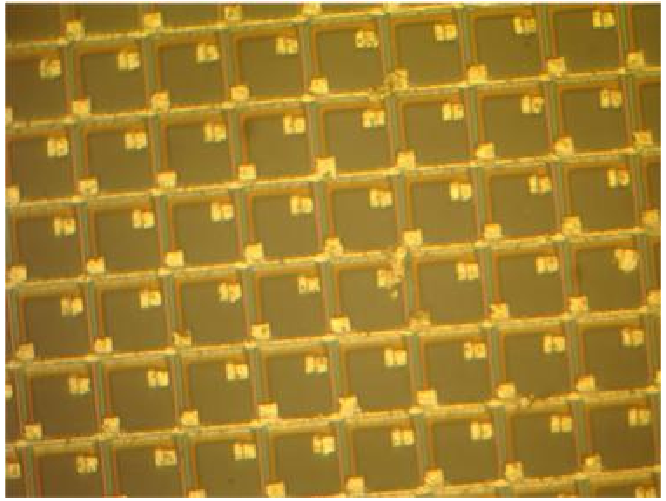


CROSS TALK

OPEN PROBLEMS WITH THE SiPM:

VERY HIGH SINGLE-ELECTRON NOISE
GEOMETRICAL EFFICIENCY LOSS DUE TO CONTACTS, RESISTORS, CROSS TALK LIMITERS:

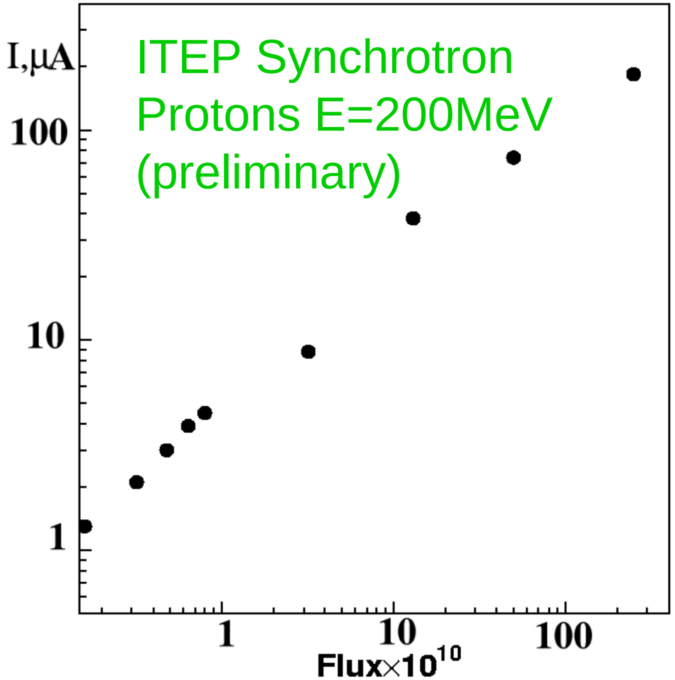
$$\frac{\textit{USEFUL}}{\textit{TOTAL AREA}} \sim 20\text{-}60\%$$



MODERATE RADIATION TOLERANCE

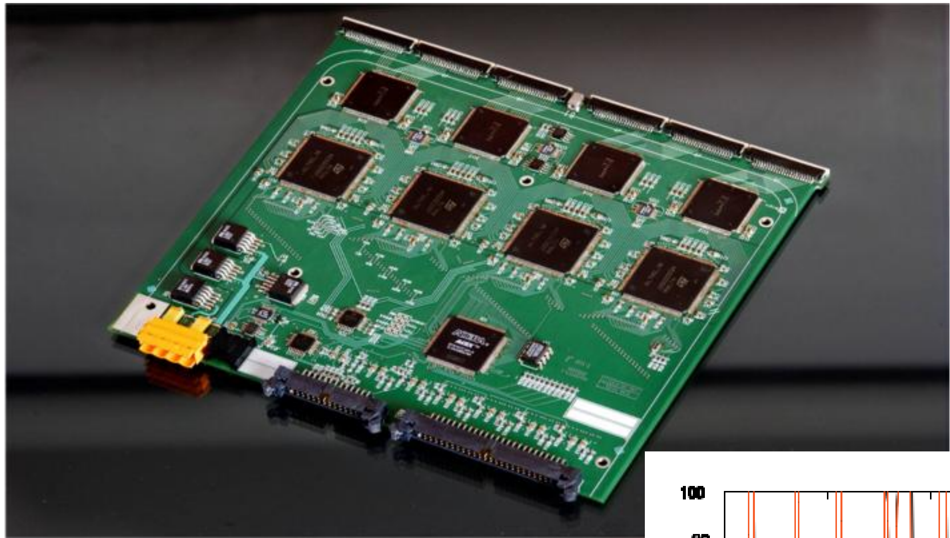
LEAKAGE CURRENT VS FLUX:

(DANILOV)



FORTHCOMING DEVELOPMENTS:
- LARGER AREAS (PRESENTLY 3x3 mm^2), ARRAYS
- ENHANCED BLUE RESPONSE (HAMAMATSU)

ADVANCES IN ELECTRONICS

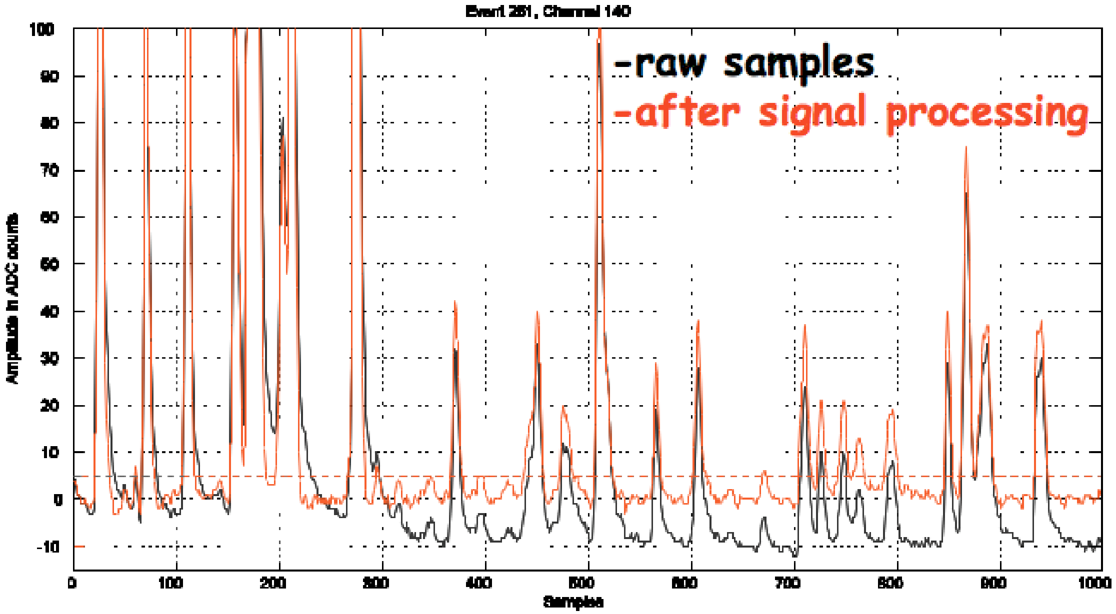


ALICE TPC READOUT

ALTRO FADC

U. FRANKENFELD

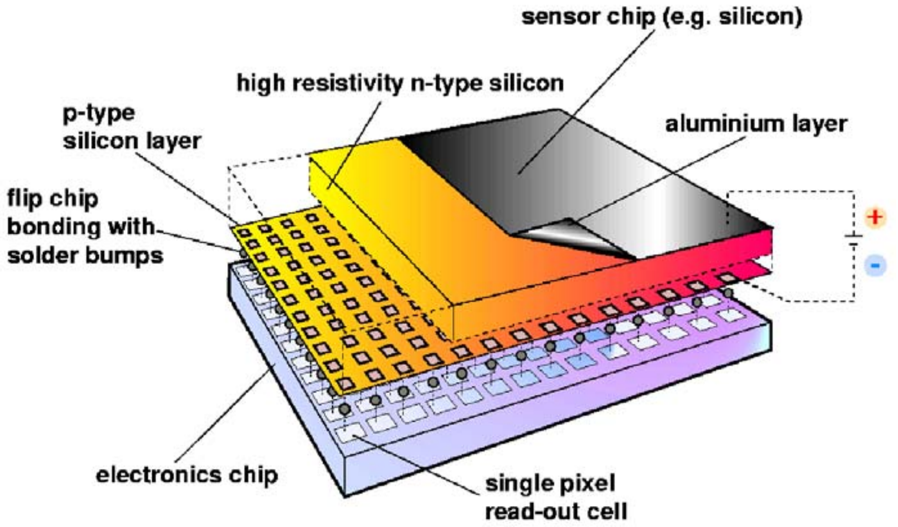
FULL BASELINE RESTORATION



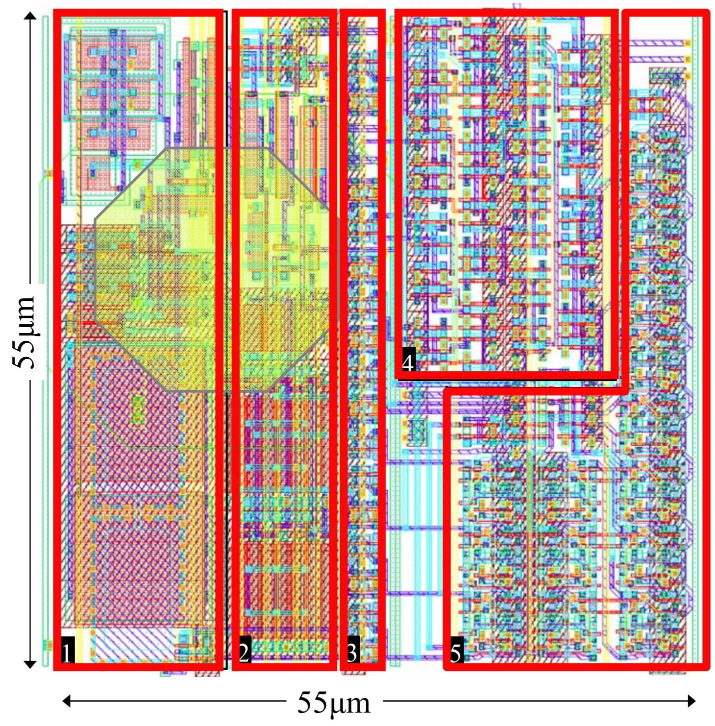
Occupancy ~ 50%

HIGHLY INTEGRATED PIXEL READOUT ELECTRONICS

MEDIPIX, TIMEPIX (X. LLOPART)



Timepix layout



MEDIPIX: CHARGE DETECTION ON PIXELS (2D)

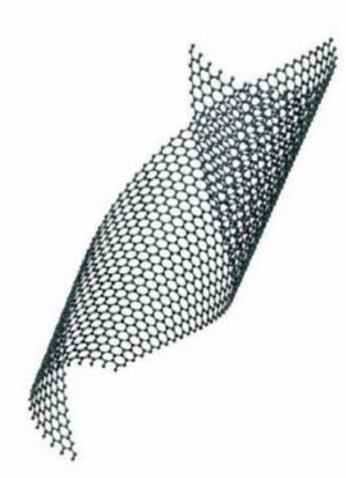
TIMEPIX: TIME-STAMPED CHARGE DETECTION (3D)

TUNABLE RESOLUTION 10 to 100 ns
TIME OVER THRESHOLD

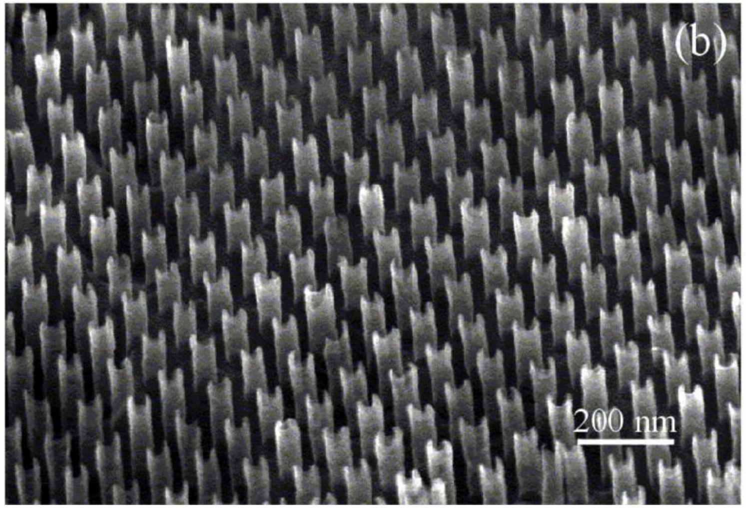
APPLICATIONS: SILICON PIXEL READOUT (MEDICAL IMAGING)
MPGD READOUT (MICTO-TPC?)

EXOTICS
CARBON NANOTUBES DETECTORS (M. AMBROSIO)

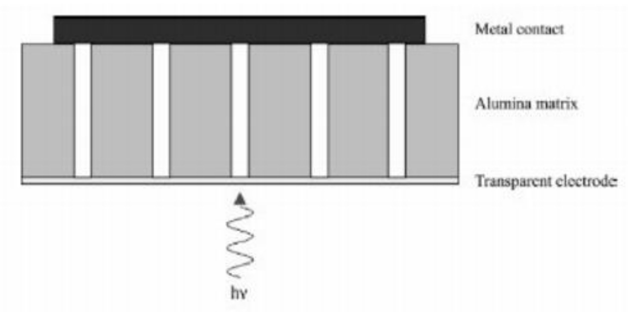
GRAPHENE SHEETS CAN BE ROLLED IN MANY SHAPES:



A NANO-NEEDLE CHAMBER?



NANOTUBE INFRARED DETECTORS:



1968:
FIRST ARTICLE ON MULTIWIRE PROPORTIONAL CHAMBERS

NUCLEAR INSTRUMENTS AND METHODS 62 (1968) 262–268; © NORTH-HOLLAND PUBLISHING CO.

THE USE OF MULTIWIRE PROPORTIONAL COUNTERS TO SELECT AND LOCALIZE CHARGED PARTICLES

G. CHARPAK, R. BOUCLIER, T. BRESSANI, J. FAVIER and Č. ZUPANČIČ

CERN, Geneva, Switzerland

Received 27 February 1968

Properties of chambers made of planes of independent wires placed between two plane electrodes have been investigated. A direct voltage is applied to the wires. It has been checked that each wire works as an independent proportional counter down to separations of 0.1 cm between wires.

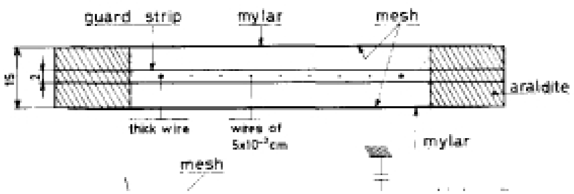
Counting rates of 10^5/wire are easily reached; time resolutions of the order of 100 nsec have been obtained in some gases; it is possible to measure the position of the tracks between the wires using the time delay of the pulses; energy resolution comparable to the one obtained with the best cylindrical chambers is observed; the chambers operate in strong magnetic fields.

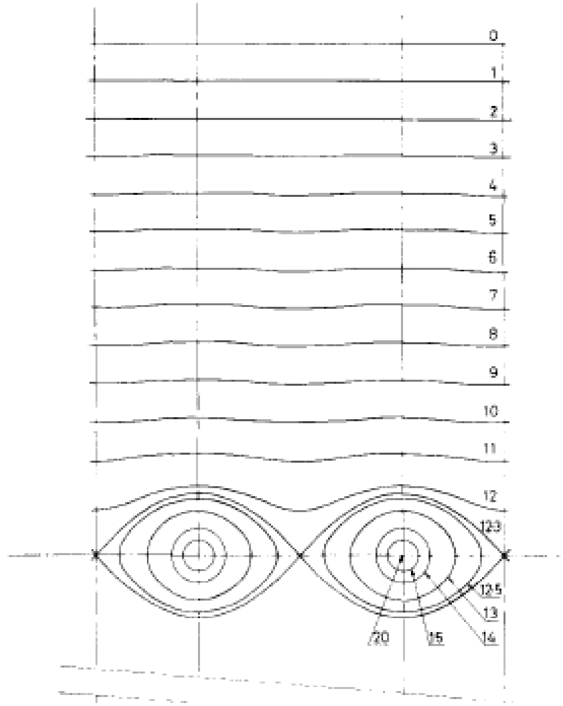
1. Introduction

Proportional counters with electrodes consisting of many parallel wires connected in parallel have been used for some years, for special applications. We have investigated the properties of chambers made up of a plane of independent wires placed between two plane electrodes. Our observations show that such chambers offer properties that can make them more advantageous than wire chambers or scintillation hodoscopes for many applications.

2. Construction

Wires of stainless steel, 4×10^{-3} cm in diameter, are stretched between two planes of stainless-steel mesh, made from wires of 5×10^{-3} cm diameter, 5×10^{-2} cm apart. The distance between the mesh and the wires is 0.75 cm. We studied the properties of chambers with wire separation $a = 0.1$, 0.2, 0.3 and 1.0 cm. A strip of metal placed at 0.1 cm from the wires, at the same potential (fig. 1), plays the same role as the guard rings in cylindrical proportional chambers. It protects the wires against breakdown along the dielectrics. It is

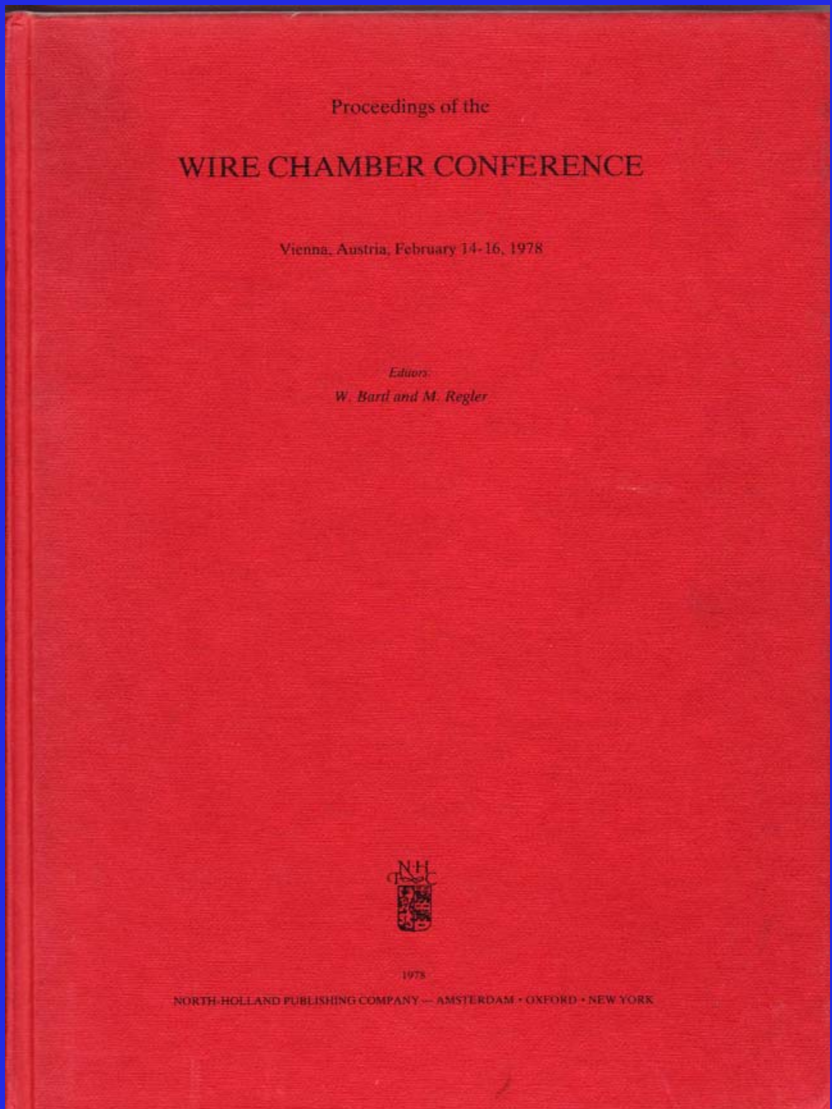


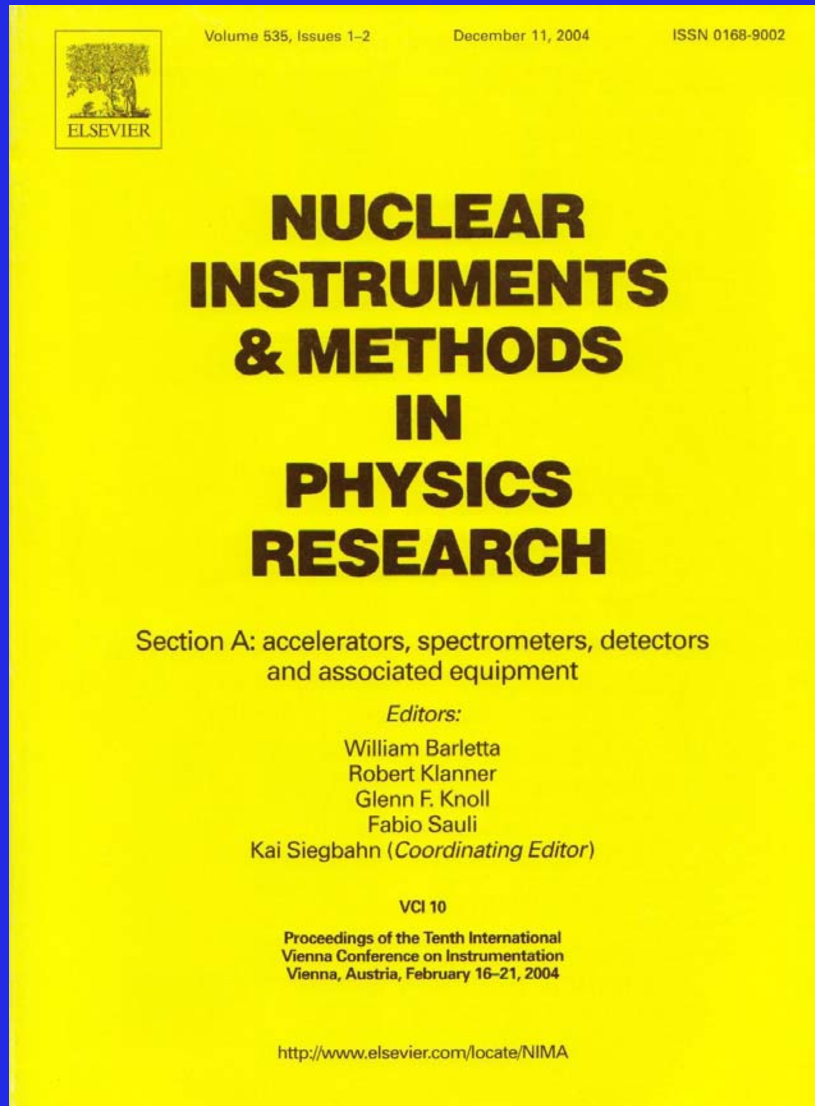


1978:
VIENNA WIRE CHAMBER CONFERENCE

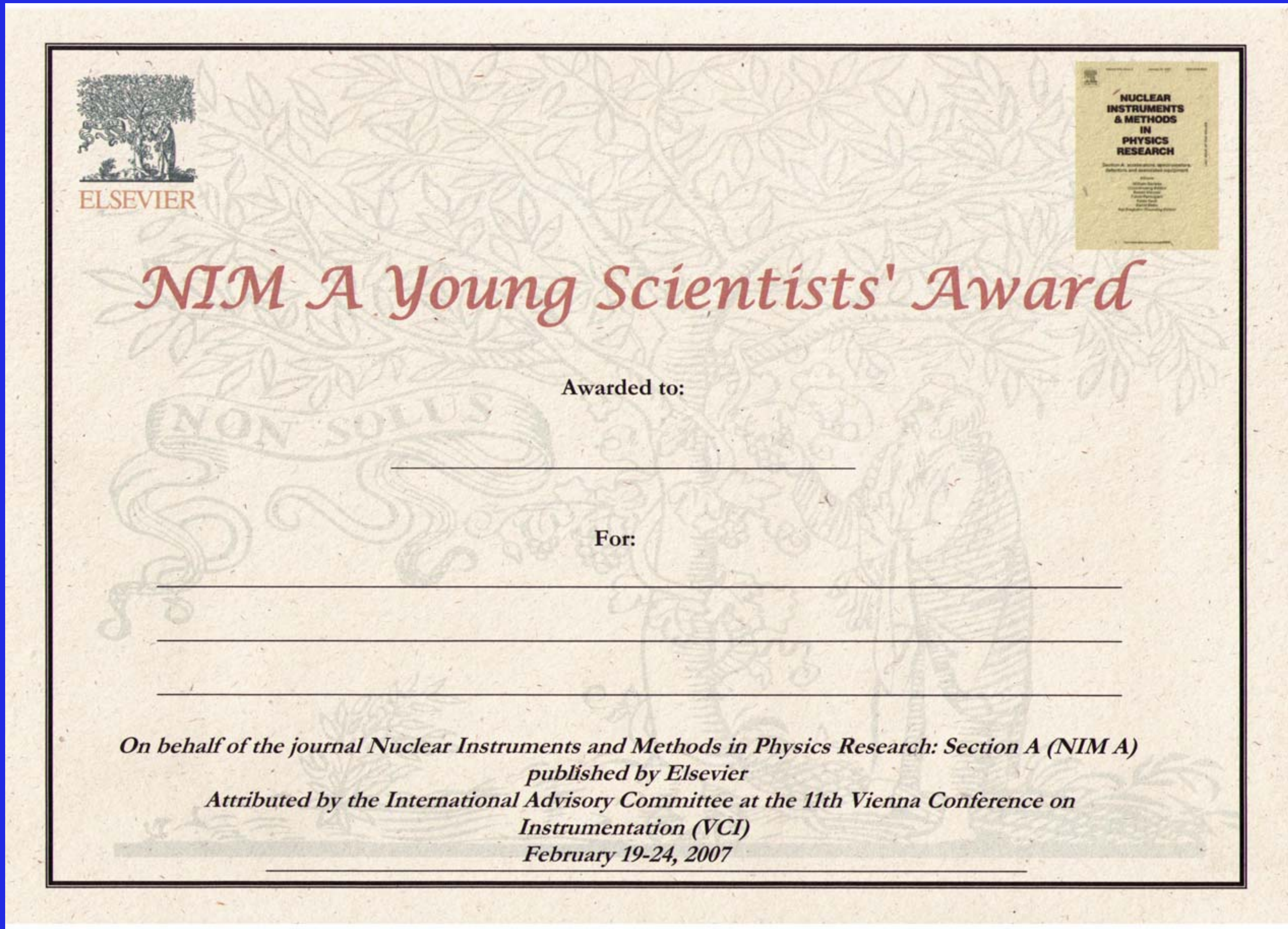
....

2004:
10^{th} VIENNA CONFERENCE ON INSTRUMENTATION





2007: 11th VIENNA CONFERENCE ON INSTRUMENTATION



ELSEVIER

NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH

NIM A Young Scientists' Award

Awarded to:

____

For:

____

____

____

On behalf of the journal Nuclear Instruments and Methods in Physics Research: Section A (NIM A)
published by Elsevier
Attributed by the International Advisory Committee at the 11th Vienna Conference on Instrumentation (VCI)
February 19-24, 2007

~~... AND THE WINNER IS....~~

... AND THE WINNERS ARE…

Nahee Park (Ewha Womans University, Seoul)

Xavier Llopart (CERN)