Readout of a TPC by Means of the MediPix CMOS Pixel Sensor

NIKHEF	Auke-Pieter Colijn Alessandro Fornaini Harry van der Graaf Peter Kluit Jan Timmermans Jan Visschers	Arno Aarts Maximilien Chefdeville Sipho van der Putten
Saclay CEA DAPNIA	Paul Colas Yannis Giomataris Arnaud Giganon	
Univ. Twente/Mesa+	Jurriaan Schmitz	
CERN/Medipix Constm	Erik Heijne Xavie Llopart Michael Campbell	

Thanks to:
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Joop Rovenkamp

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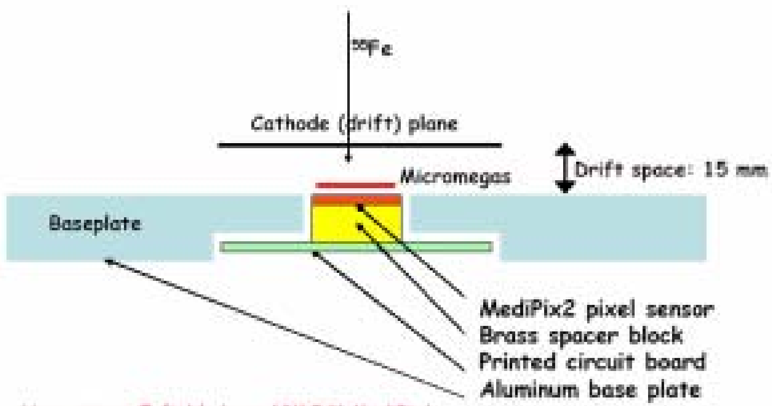
Goals

- Gas multiplication GEM or Micromegas foil(s)
- Charge collection with granularity matching primary ionisation cluster spread
- Needs sufficiently low diffusion gas
- dE/dx using cluster counting? ($\rightarrow$ M. Hauschild)

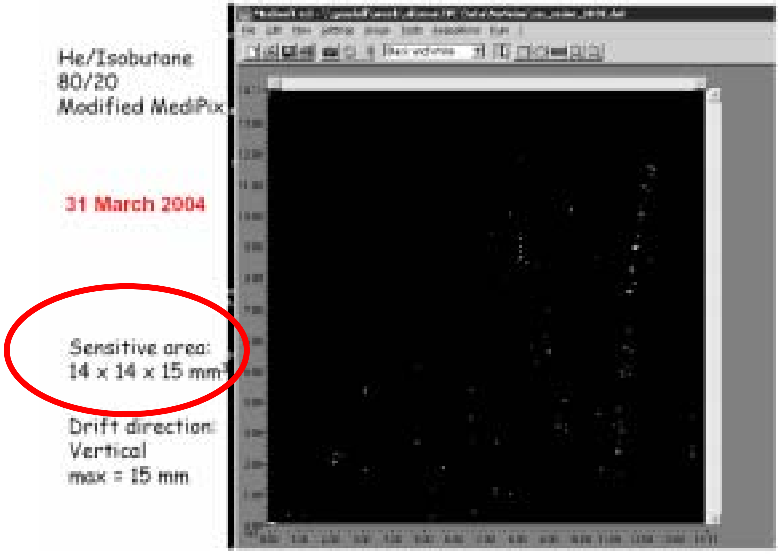
- Proof of principle based on existing Medipix2 readout chip

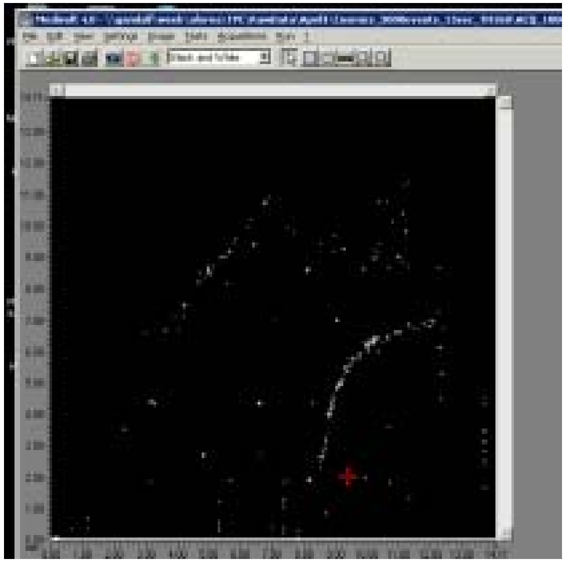
Results pixel readout gas detectors

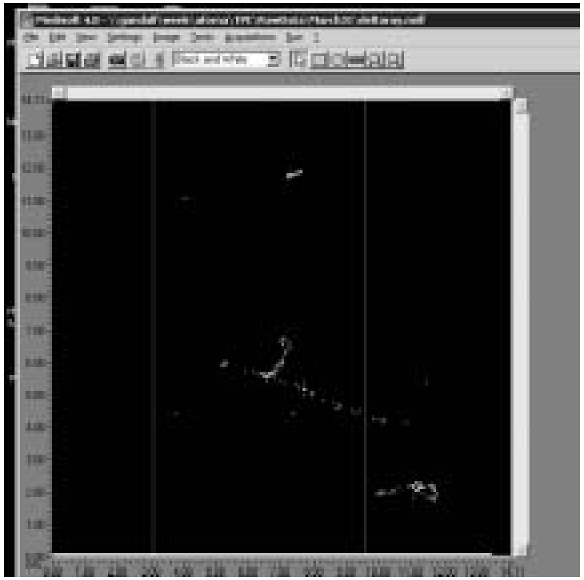
With Paul Colas & Ioannis Giomataris:
MediPix2 & Micromegas



Very strong E-field above (CMOS) MediPix!







δ ray

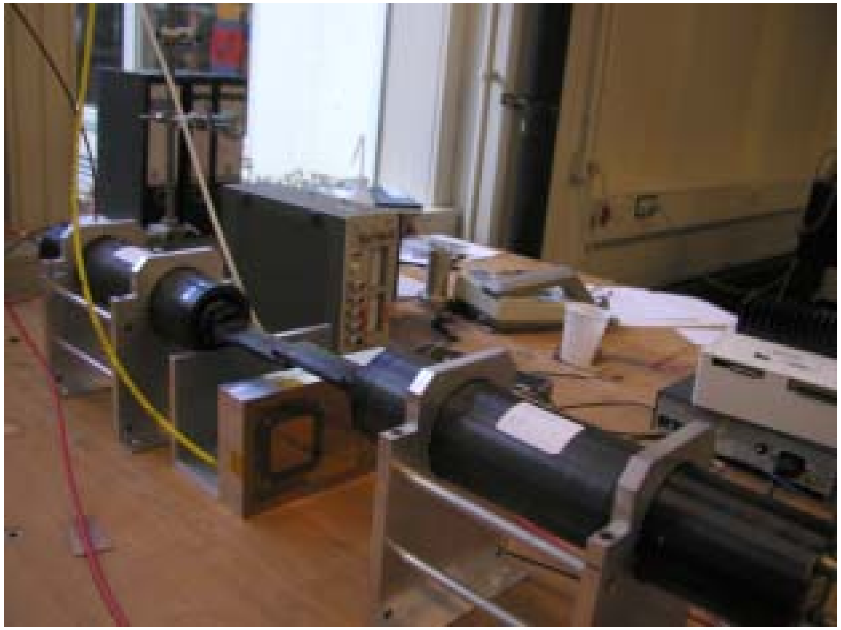
Observation of min. ionising cosmic muons: high spatial resolution + individual cluster counting !

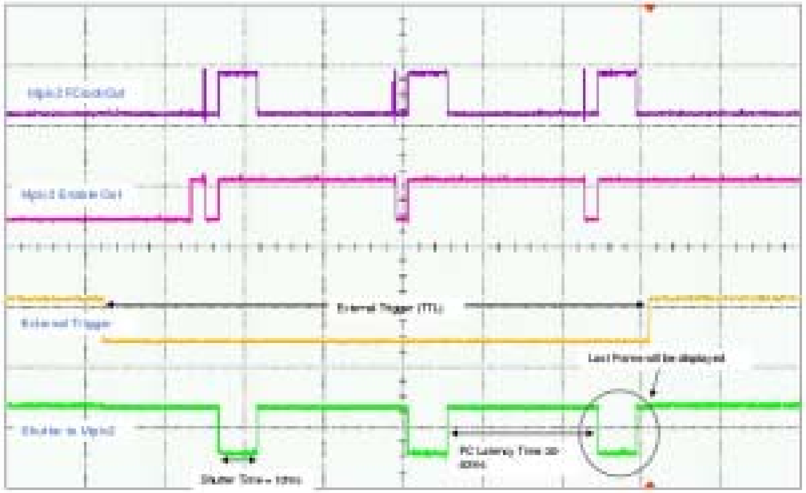
Detection of single electrons using MediPix2/Micromegas assembly as Direct Pixel Segmented Anode

- NIM A540 (2005) 295 (physics/0409048)
- #pixels hit/mm track length = 1.83
- #clusters/mm track length = 0.52
- Single electron efficiency 0.9
- Moire effects: mismatch in pixel and hole pitch: 60/(60-55) = 12 pixels repetition

Recent work (with new Micromegas and new MediPix):

- Threshold studies (equalisation)
- Implementation external trigger (needed new Medipix software and interface box); it works!
- New data taking: much lower single electron efficiency (not yet understood)
- Kept MediPix chip alive for about 4 weeks!

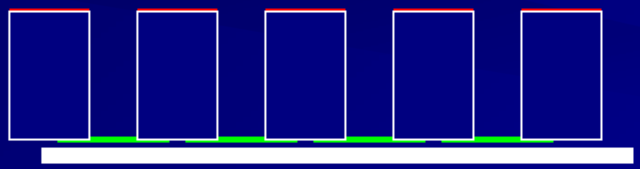




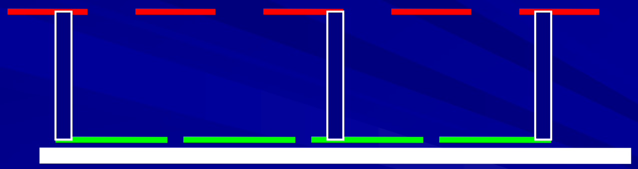
InGrid

Integrate GEM/Micromegas and pixel sensor

‘GEM’



‘Micromegas’



By ‘wafer post processing’

Wafer dia.: 100 mm

30 fields with variety of pillar geometry

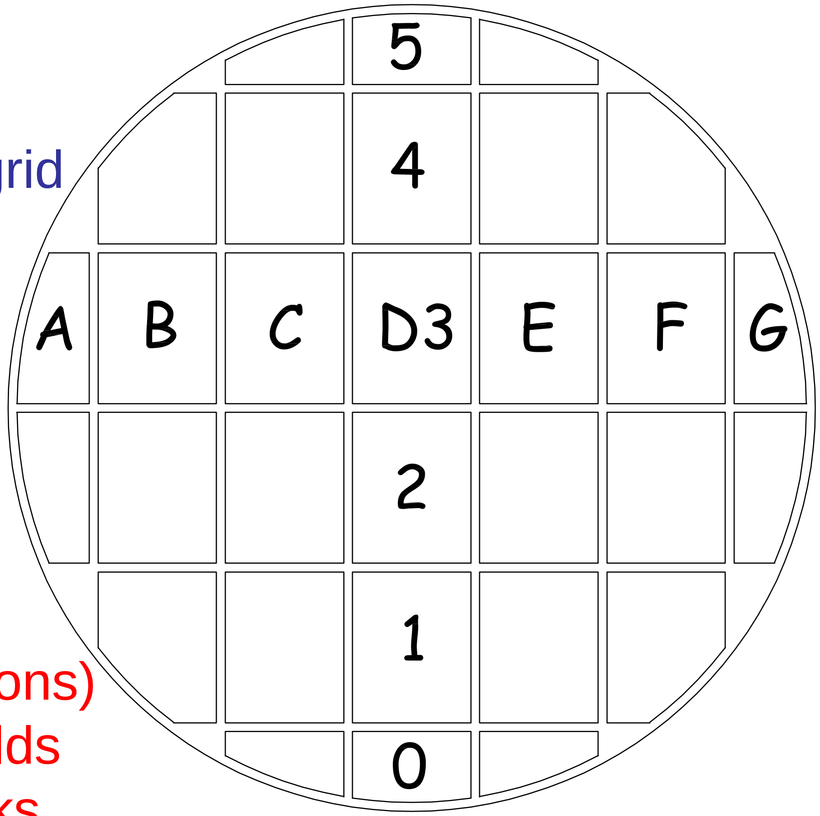
First trials with pillars look OK

Had some problems with 'Micromegas' grid
(holes closed with very thin layer)

First 'good' Ingrid in Feb. 2005

Reached 170V before breakdown
(after that 80V with 4.6µA current)

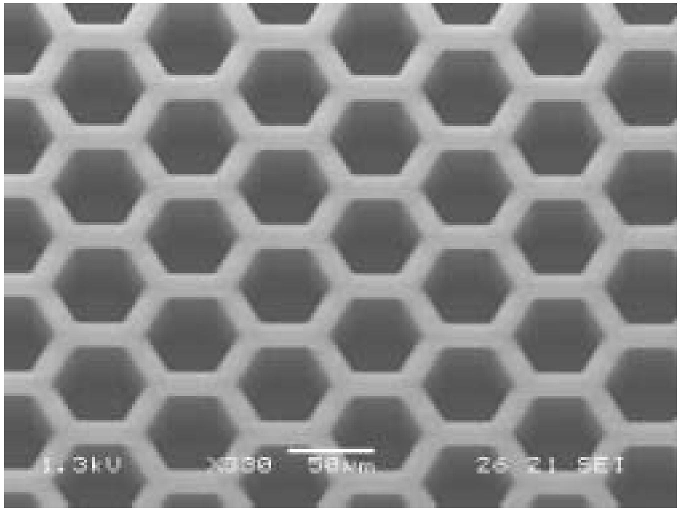
New design: -thicker grid layer (few microns)
-larger spacing between fields
-could be ready in few weeks



INGRID: some first trials

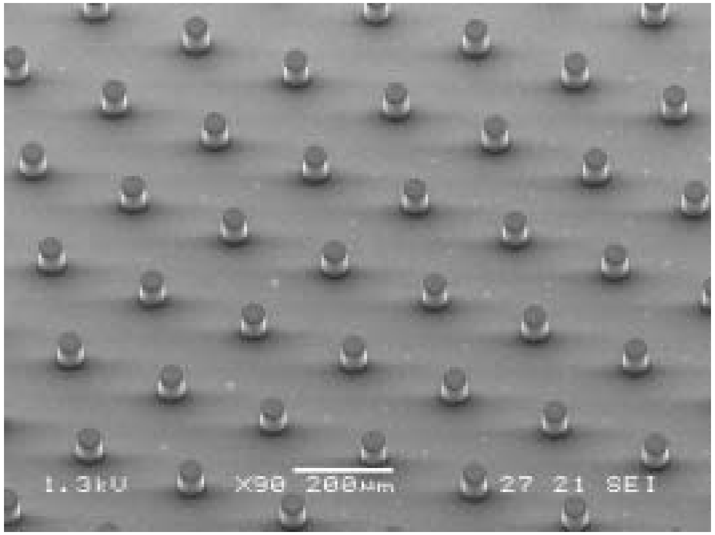
Various pitches, shapes

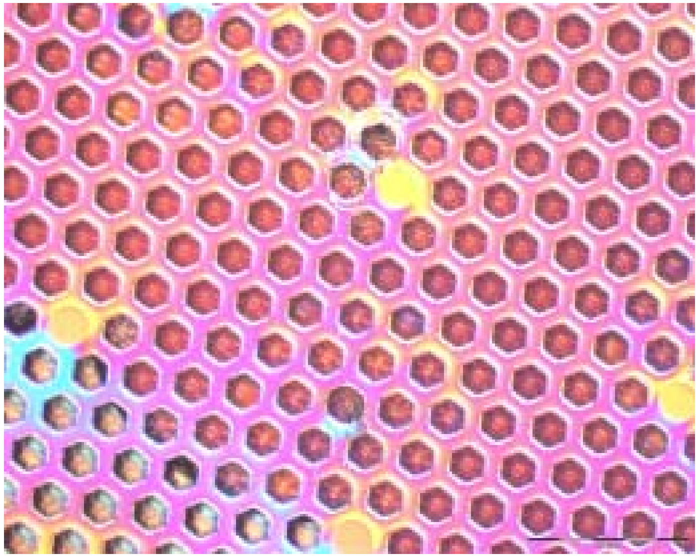
By 'wafer post processing' at MESA+, Univ. of Twente



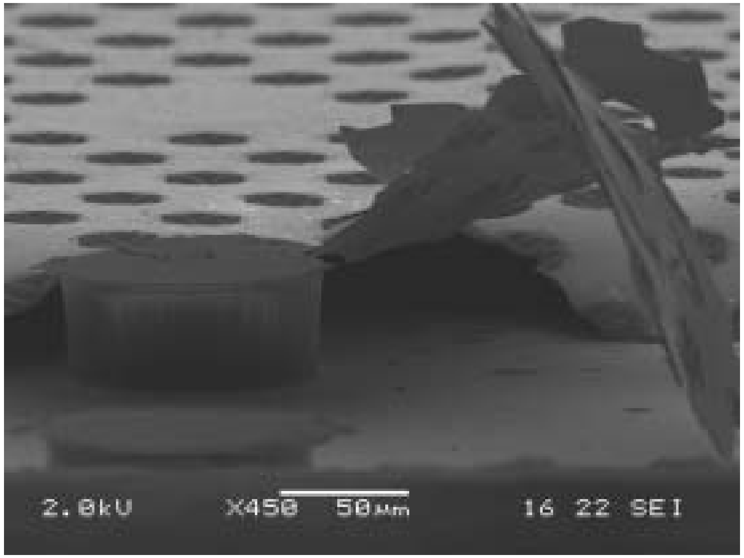
pads

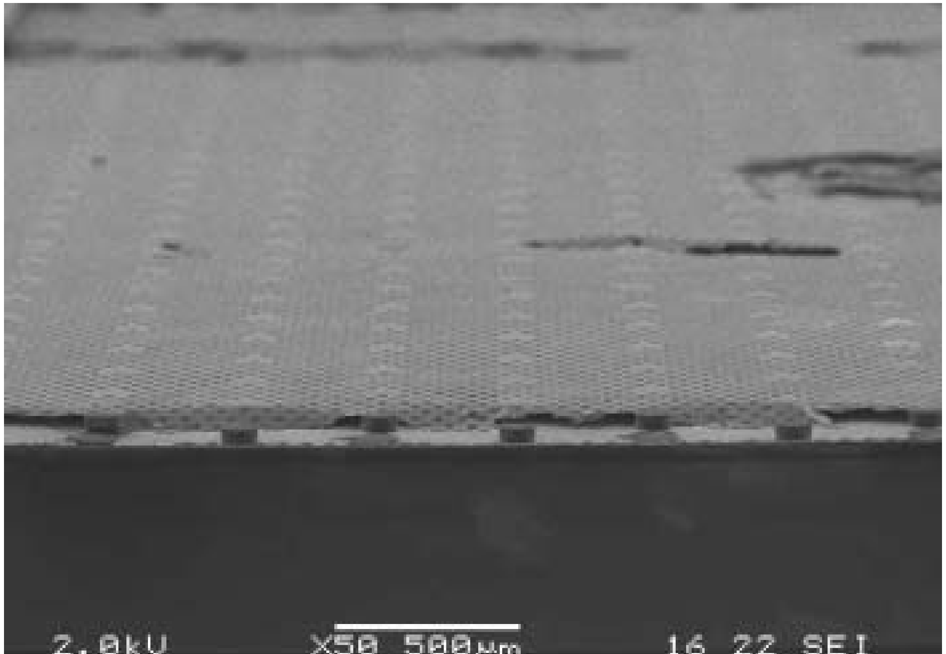
pillars

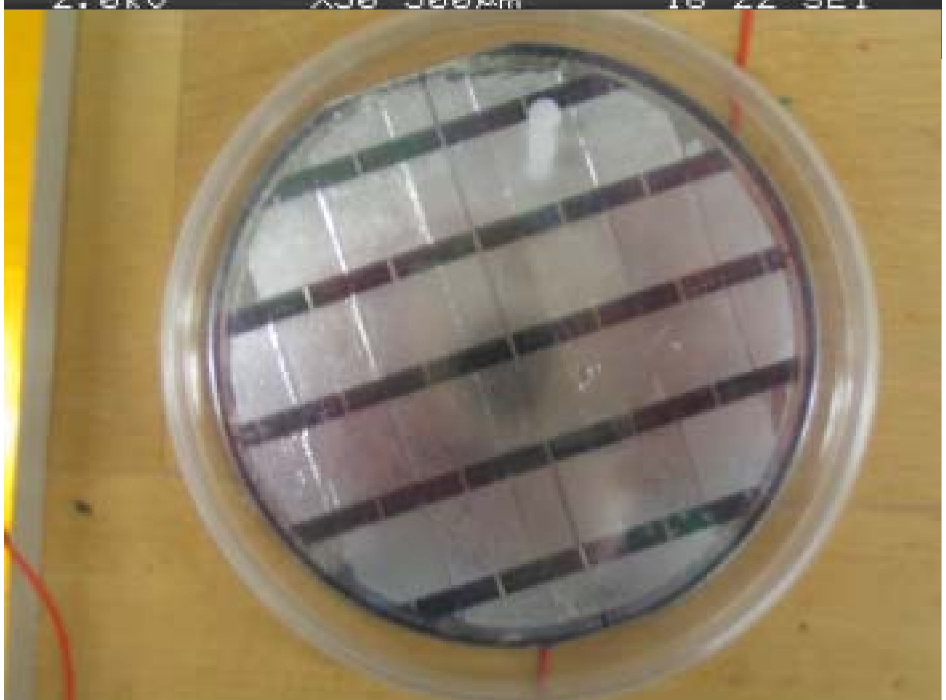


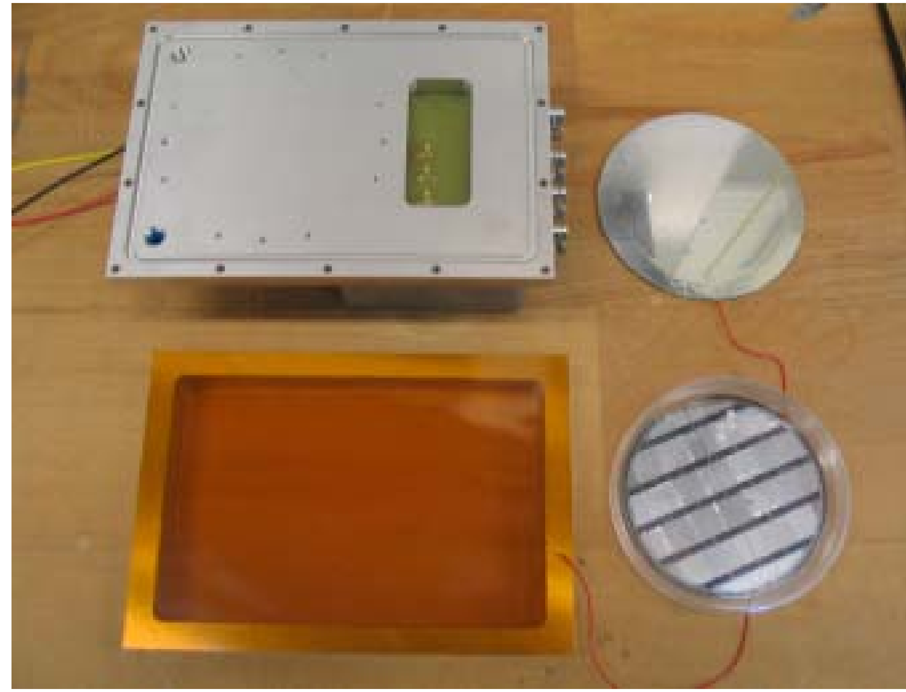


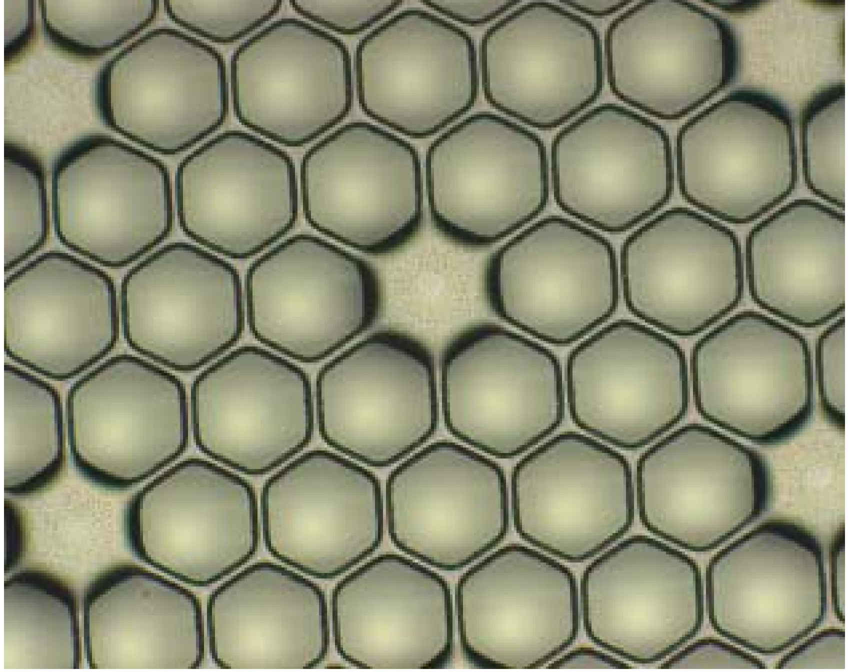
grid foils



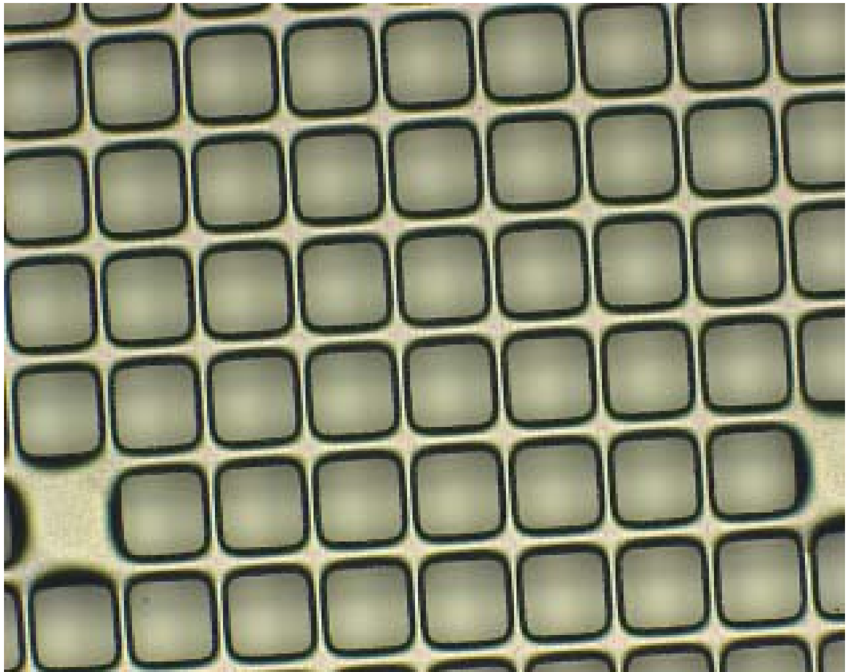

2.0kV X50 500μm 16 22 SEI

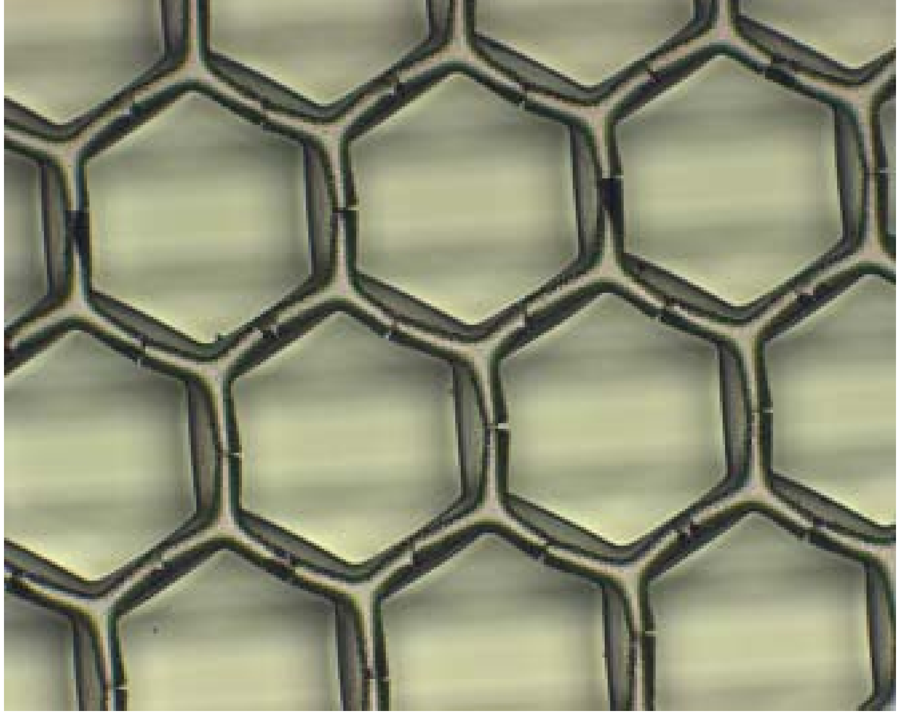






with pillars





with walls

How to proceed?

TimePix Proposal Nov 2004

The TimePix R&D Collaboration

Harry van der Graaf, Jan Timmermans*, Jan Visschers
NIKHEF, Amsterdam, The Netherlands

Michael Campbell, CERN, Geneva, Switzerland

Paul Colas, DAPNIA, CEA Saclay, France

1. Introduction

Ongoing miniaturization of electronics circuits has caused the "digital revolution": in a state-of-the-art deep submicron chip, operations can be performed at higher than 1 GHz clock frequency and at exceedingly low power consumption. Signal processing and data conversion circuits have become so small that they can be included on the pixel-level, and this is presently causing a revolution in the world of micro patterned semi-conducting detectors for ionizing radiation, for High-Energy Physics, as well as for other applications.

Preliminary experiments with the Medipix2 photon counting pixel detector [ref 1] have convinced us that these deep-submicron electronics technologies will also cause a change of paradigm in the world of gaseous detector readout. The Medipix2 detector is a detector

Modify MediPix2 counters for (drift)time measurements
(~10 ns resolution)

TimePix1

- Distribute clock to full 256x256 pixel matrix (100-160MHz)
- Enable counting by first hit after ‘shutter’ opens, until ‘shutter’ closes (common stop)
- Dynamic range 2^{14} x 10 ns = 160 µs
- (for the time being) no zero-suppress to remain fully compatible with Medipix2
- Shaping time ~200 ns, might be reduced for TimePix
- Extra static discharge protection for the front-end will be considered
- Keep same chip-size, pixel-size, readout protocol
- Can be done in 5-6 months (if done by MediPix2 designers)

- 2 full-reticule submits in 0.25µm via CERN-MIC to IBM:
  one engineering run (~6 wafers 600 chips)
  one production run (~48 wafers)

Common Fund: (in k€)	2005	2006
6 month chip designer	40	
Engineering Run IBM	150	
Production Run IBM		150
Dicing and consumables	10	
TOTAL	**200**	**150**

- Need ~6 partners paying 30 k€ each in BOTH in 2005 and 2006
- plus demonstrator system ~€4600 (PC, NI DIO card, MUROS interface card and 2 cables

- 4 institutes have expressed intention allocating money: CERN, NIKHEF, Saclay, Freiburg

- But apart from reactions like ‘very interesting idea’, ‘breakthrough’, …

- No(!) further positive feedback since distributing this proposal to LC-TPC and MediPix2 mailing lists + few individuals

Further Tests and Developments

- Investigate possible use of CMS (or Atlas) frontend pixel chip
- Ageing tests for….
- GOSSIP: very thin gas/pixel detectors as Vertex Detector (LHC/ILC) (TIMEPIX2 with ~1 ns resolution)
- Chip tiling: large(r) detector surfaces (2x2, 2x4 chips)
- Through Si connectivity: avoiding bonding wires
- Fast readout technology

  (~5 Gb/s)