Read-out boards

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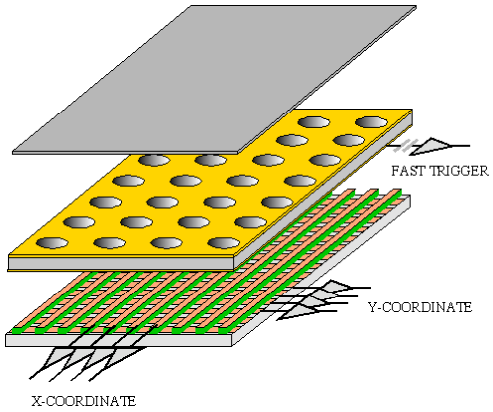
RD51 WG1 workshop Geneva

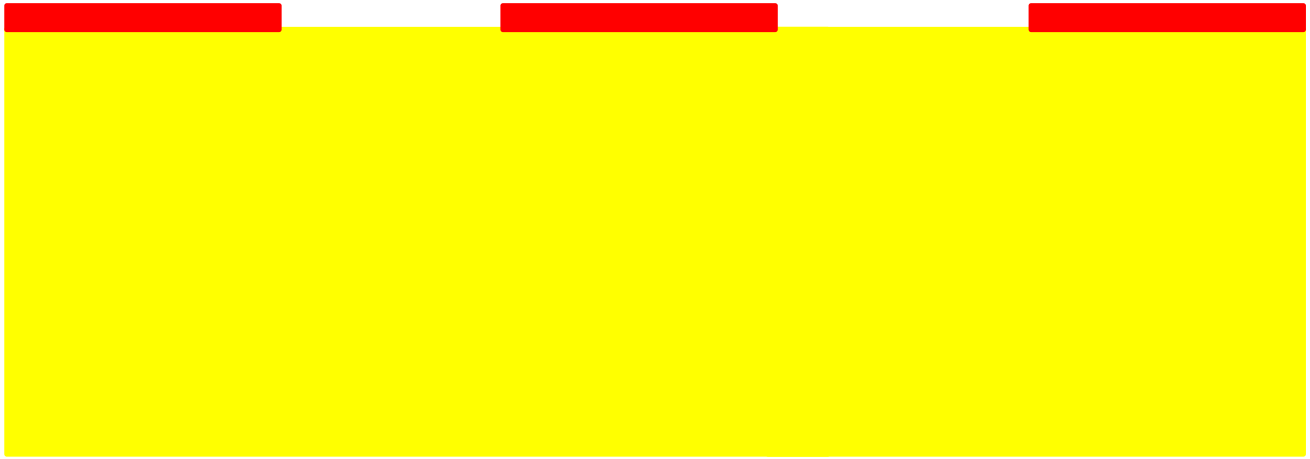
Content

- PCB structures
- 1 direction read out board
- 2 directions
- 3 directions
- PAD
- Pixel
- Special
  - Active read out board
  - Grounding and capacitive couplings
  - Resistive spark protection
  - Resistive sharing



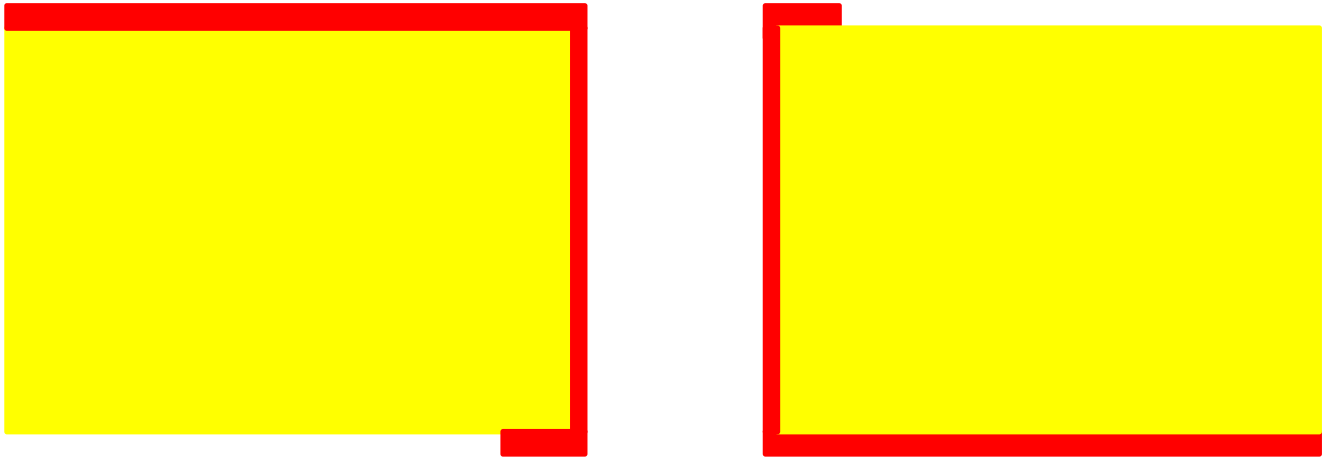
Single sided

CERN max size: 2000 x 600
Board thickness : 12um to 6mm
Metal: 2um to 200um
Limitation : exposure 2000x600
dev, etch : 600 width
Materials: rigid glass epoxy etc...
flex



Double sided +PTH

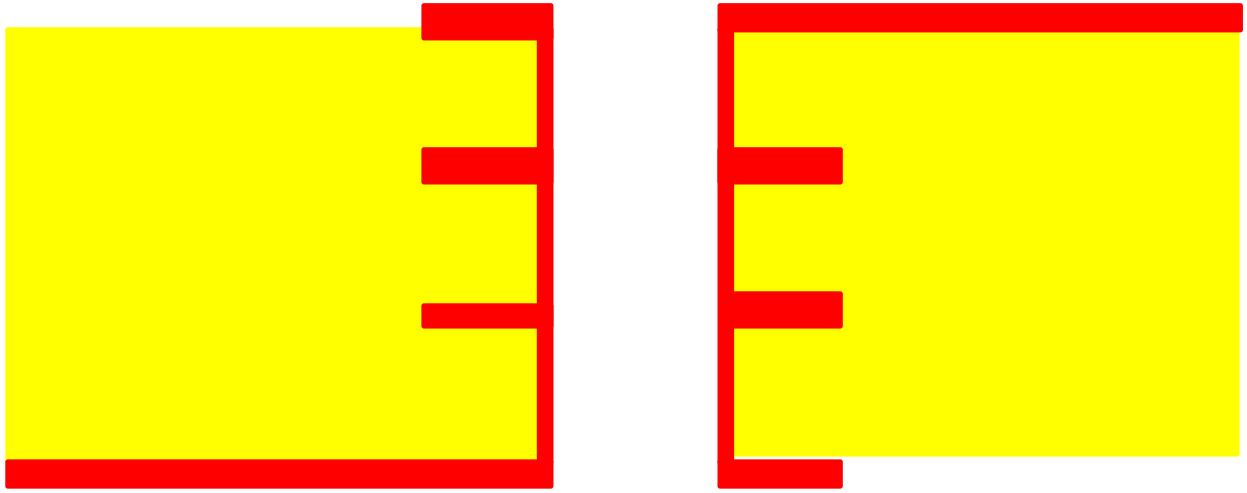
Drilling: 0.2 mm CNC min , 50um micro-vias
CERN max size: 1200 x 600 rigid boards
1600 x 600 flex boards
Limitation due to plating baths
Board thickness : 12um to 6mm
Metal:15um to 200um in the holes , 2 um min elsewhere
Materials : glass epoxy , polyimide



Multi layer + PTH

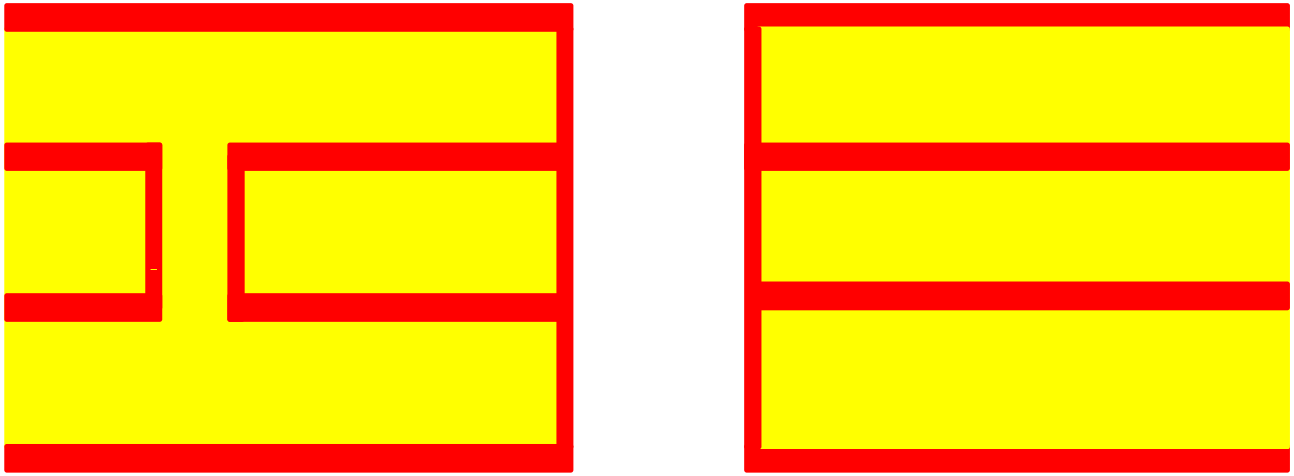
Drilling: 0.2 mm CNC min
CERN max size: 600 x 600
Board thickness : 6mm max
Metal:15um to 200um
Limitation due to: press and plating
Number of layers up to 20

Thickness of one layer : 12um min
Materials: Epoxy , Kapton ...



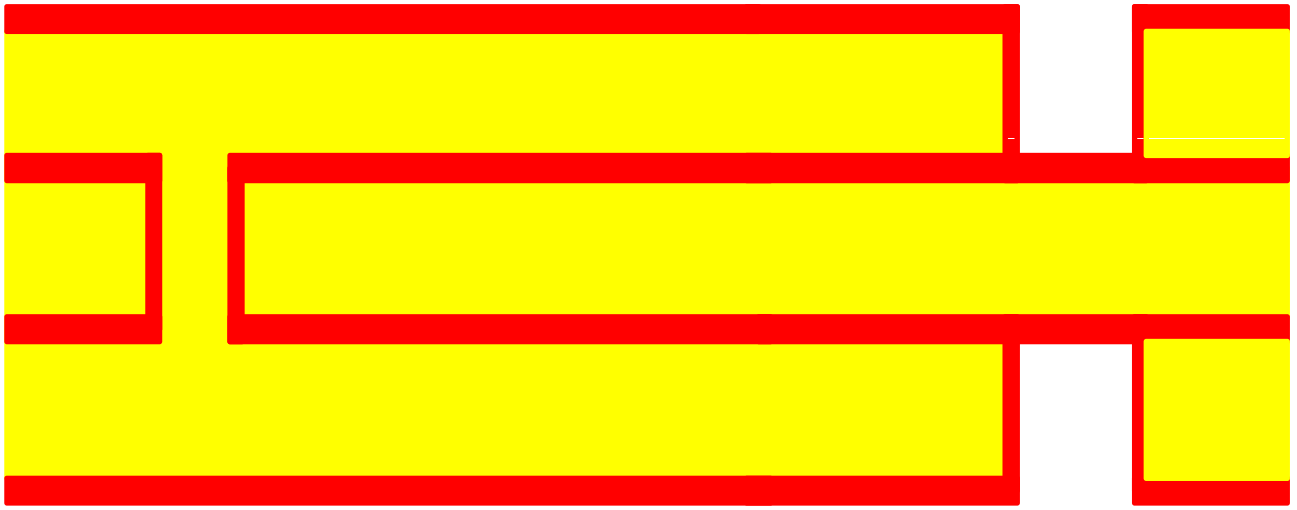
Multi layer + burried Vias +PTH

Same limitations as multi layers boards
Burried vias: 50um min Chemical, and 0.2mm for CNC drilling



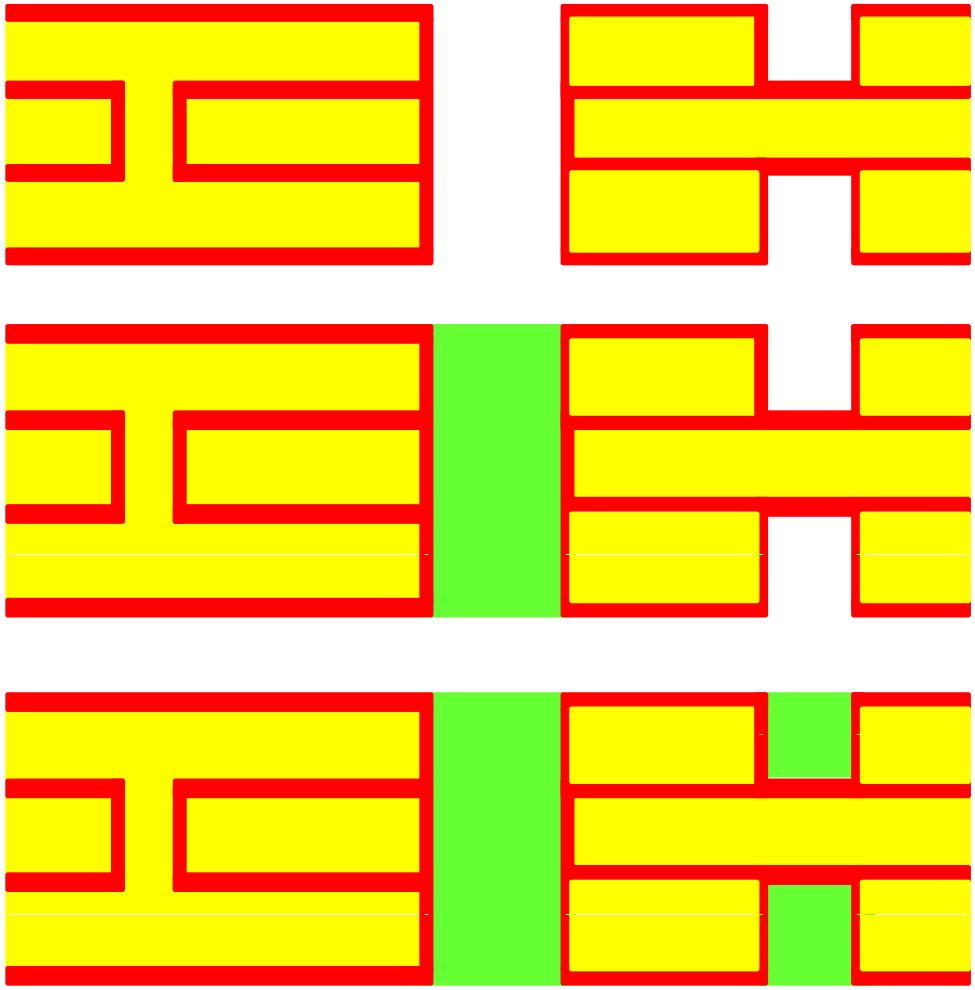
Multi layer + burried Vias +blind vias

Same limitations as multi layers boards
Burried vias: 50um min for Chemical vias and 0.2mm for CNC drilling
Blind vias : hole diameter/ hole depth > 1
Hermetic by process



Multi layer + burried Vias +blind vias+ PTH

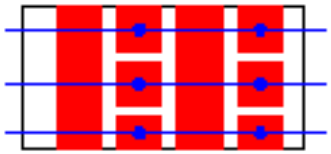
Hole and via filling
Conductive or
Dielectric resin
Not gas tight

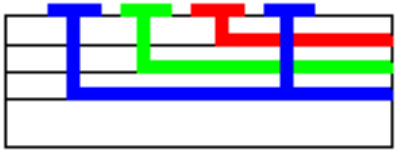


Readout Circuits

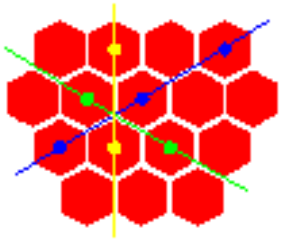
1 Direction

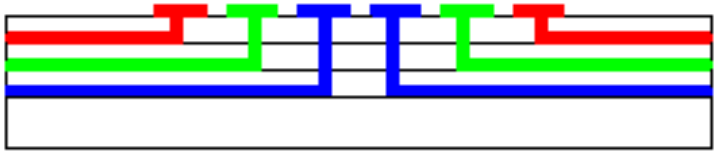
2 Directions



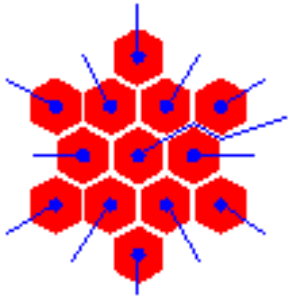


3 Directions “3D”

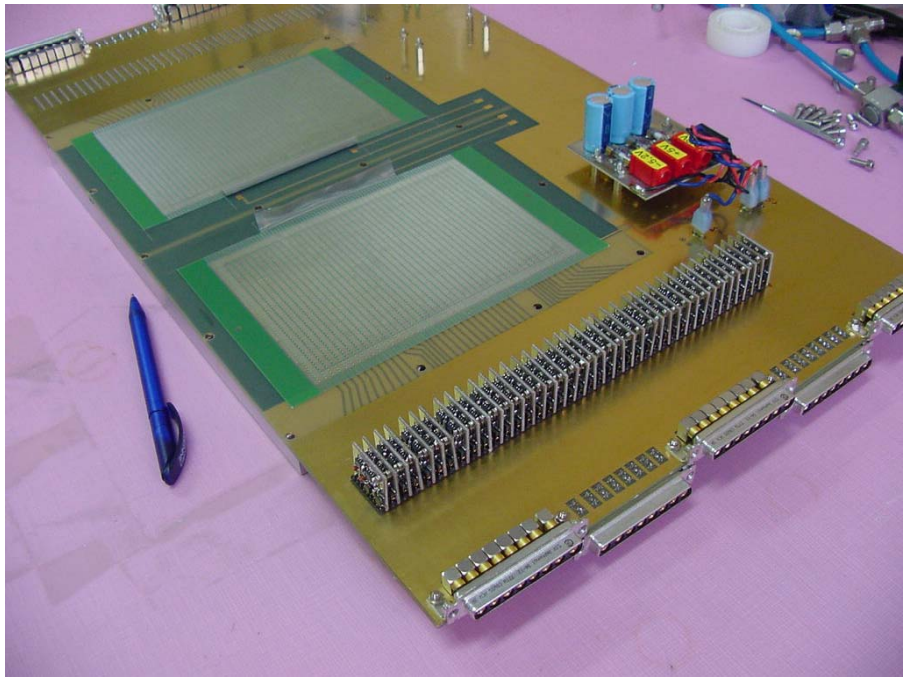




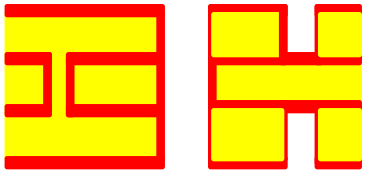
Pixel
PAD



1D Demin experiment

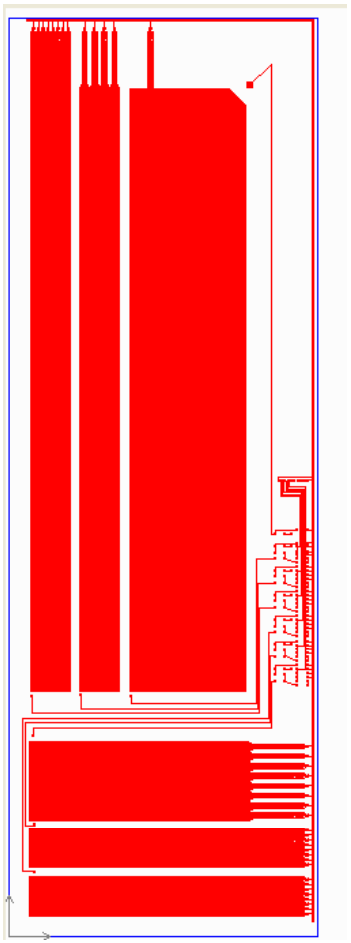


Multilayer + PTH+ Burried +blind



Single direction read out board with shielding and reduced copper in the active region.
Max size 600mm x 600mm

1D



ATLAS Muon detector Upgrade test
Single side rigid epoxy board
17um copper on 2mm glass epoxy
1500mm x 500 mm

2D

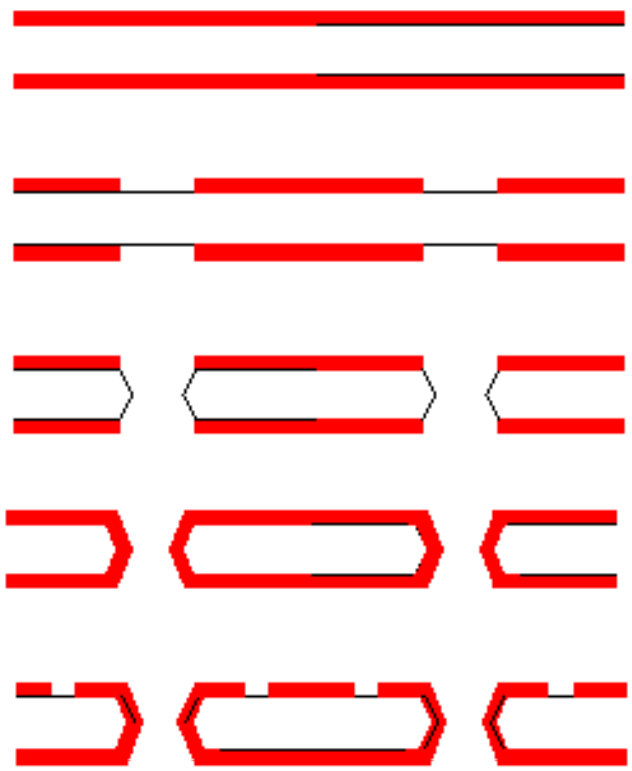
Polyimide
50 um

Image the
micro-vias

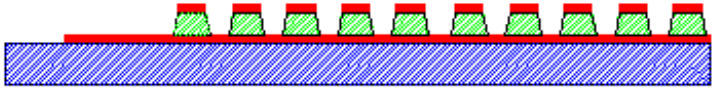
Chemical
drilling

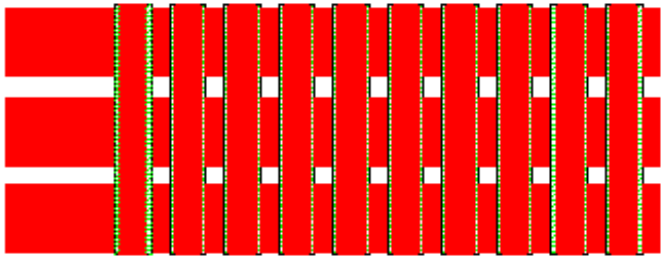
Metallization
15 um

Photolitho



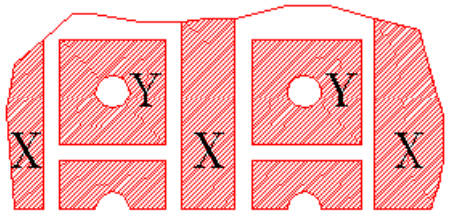
or



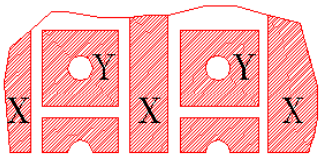


area of X and Y adjusted
To share the signals

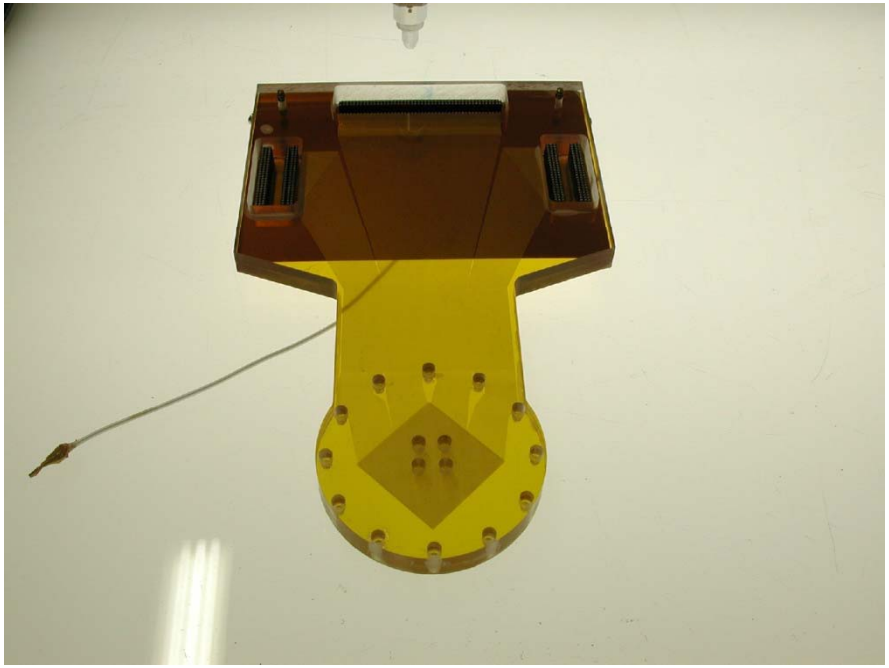
area of X = area of Y

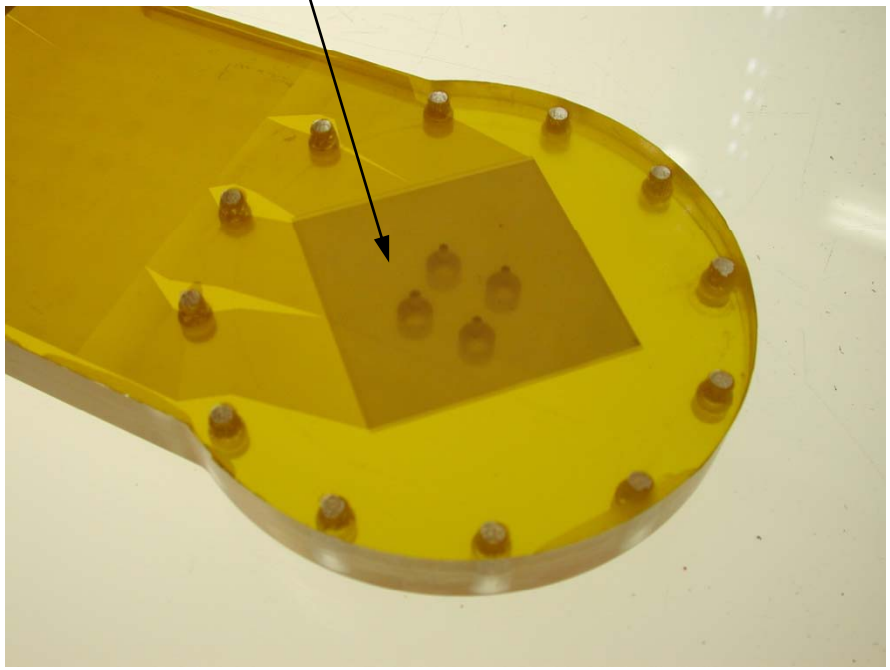


2D



Readout active area





2D readout board glued on low intrinsic radiation Plexiglas substrate
CAST experiment
400 um pitch min
600mm x 450mm max size

2D

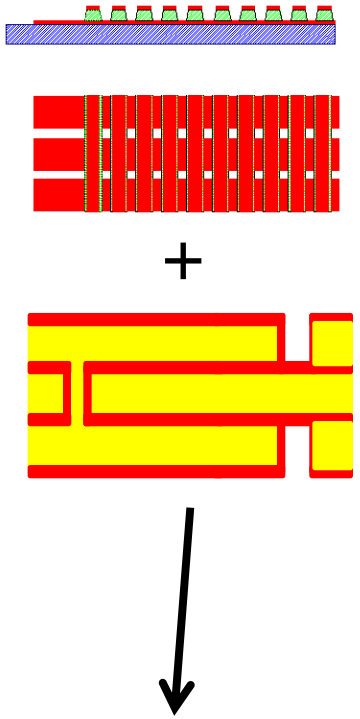
Compass experiment 33cm x 33cm active area

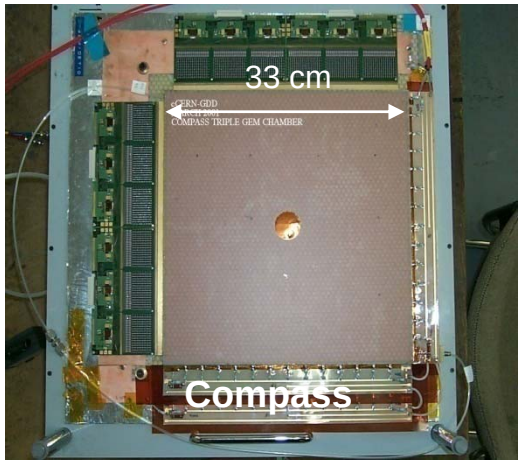
NA 49 half cylindrical detector.

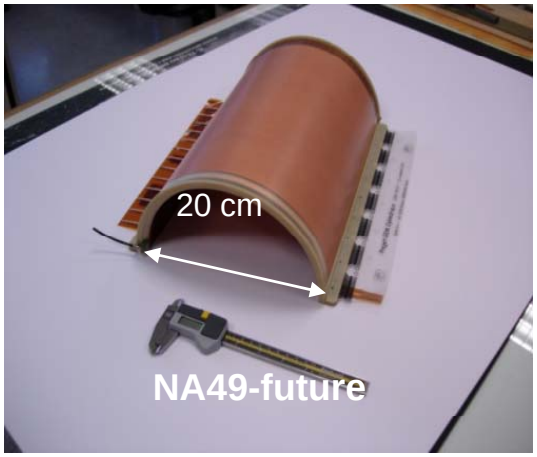
Max size : 600 x 450

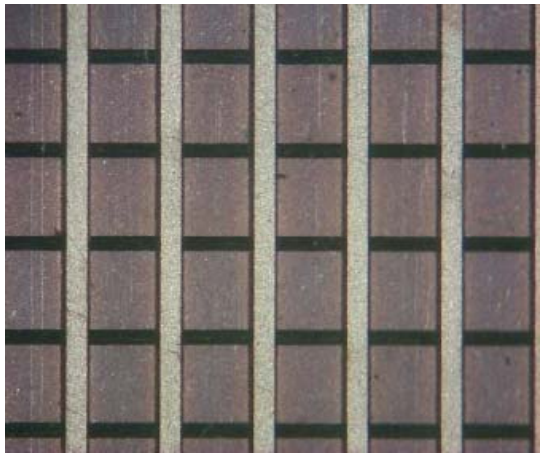
Limited by raw material, press and plating baths

Minimum thickness : 35 to 50 um Kapton + 5um copper + Honey comb structure



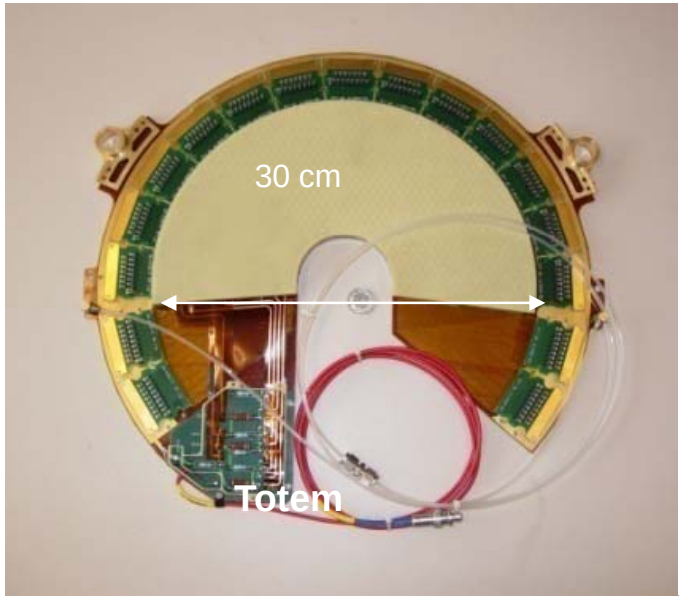






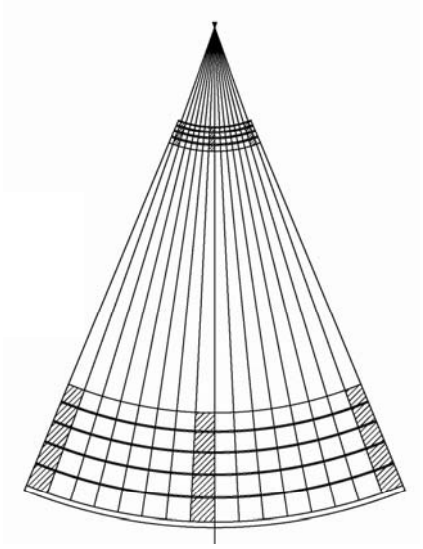
400 um pitch X and Y

2D



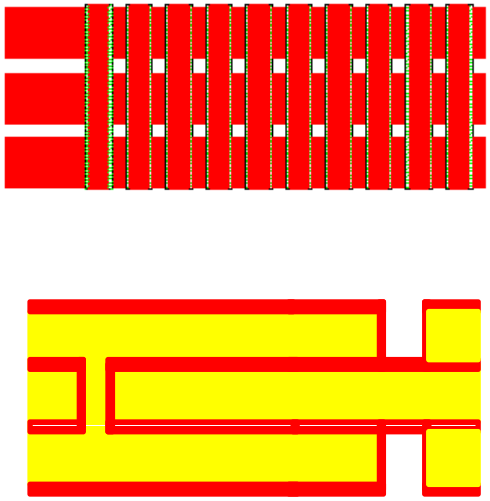
TOTEM experiment

Max size for this technology :
600mm x 450mm



Polar pads

+



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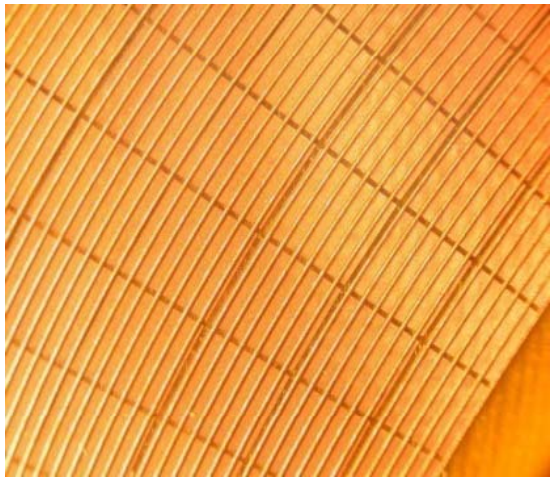
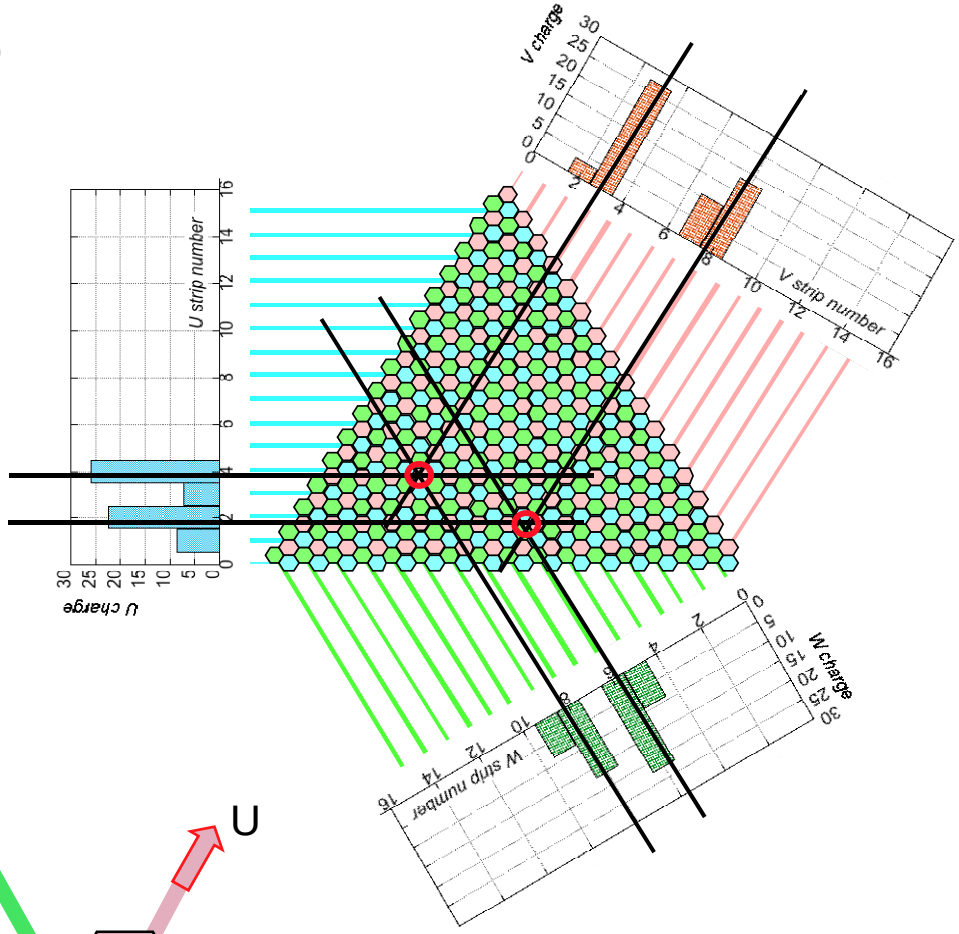
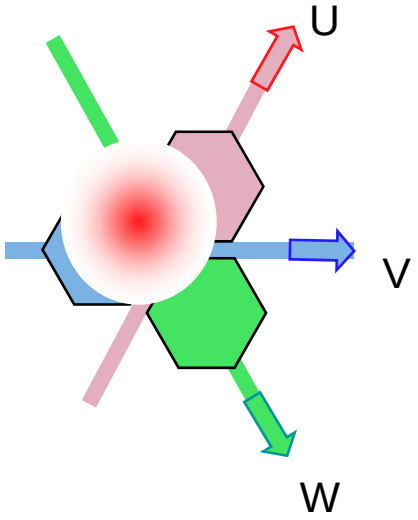
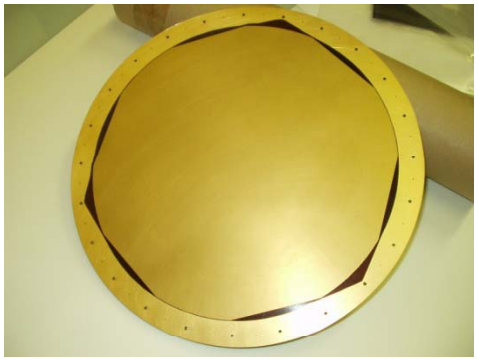


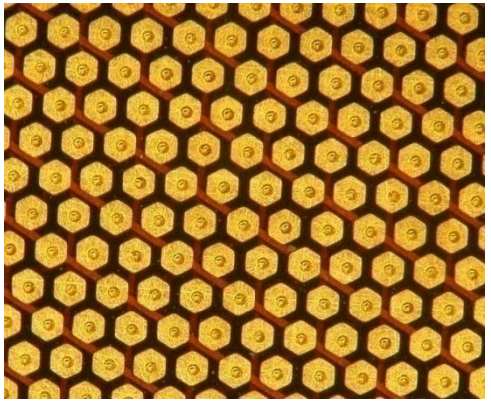
3D

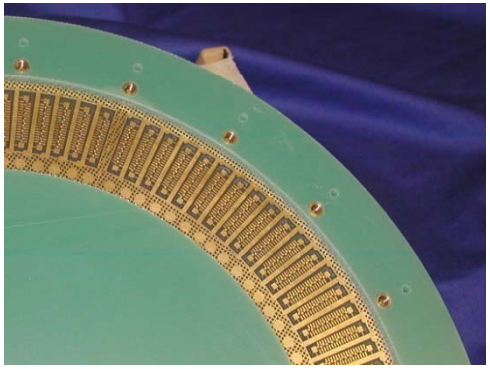


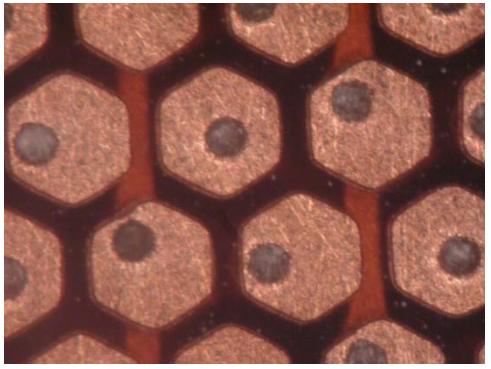


Mice Experiment, 350um cell
30cm active area



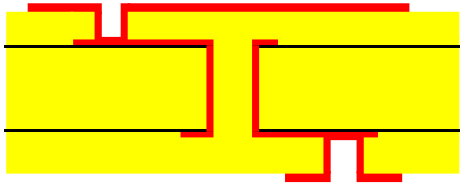


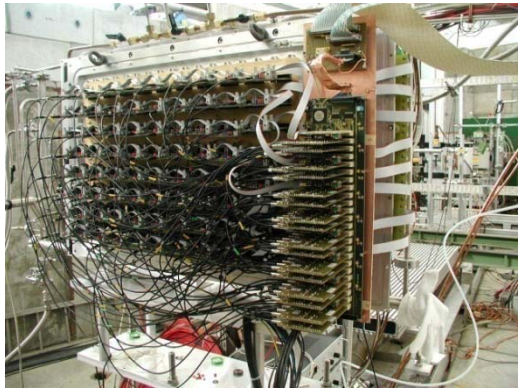


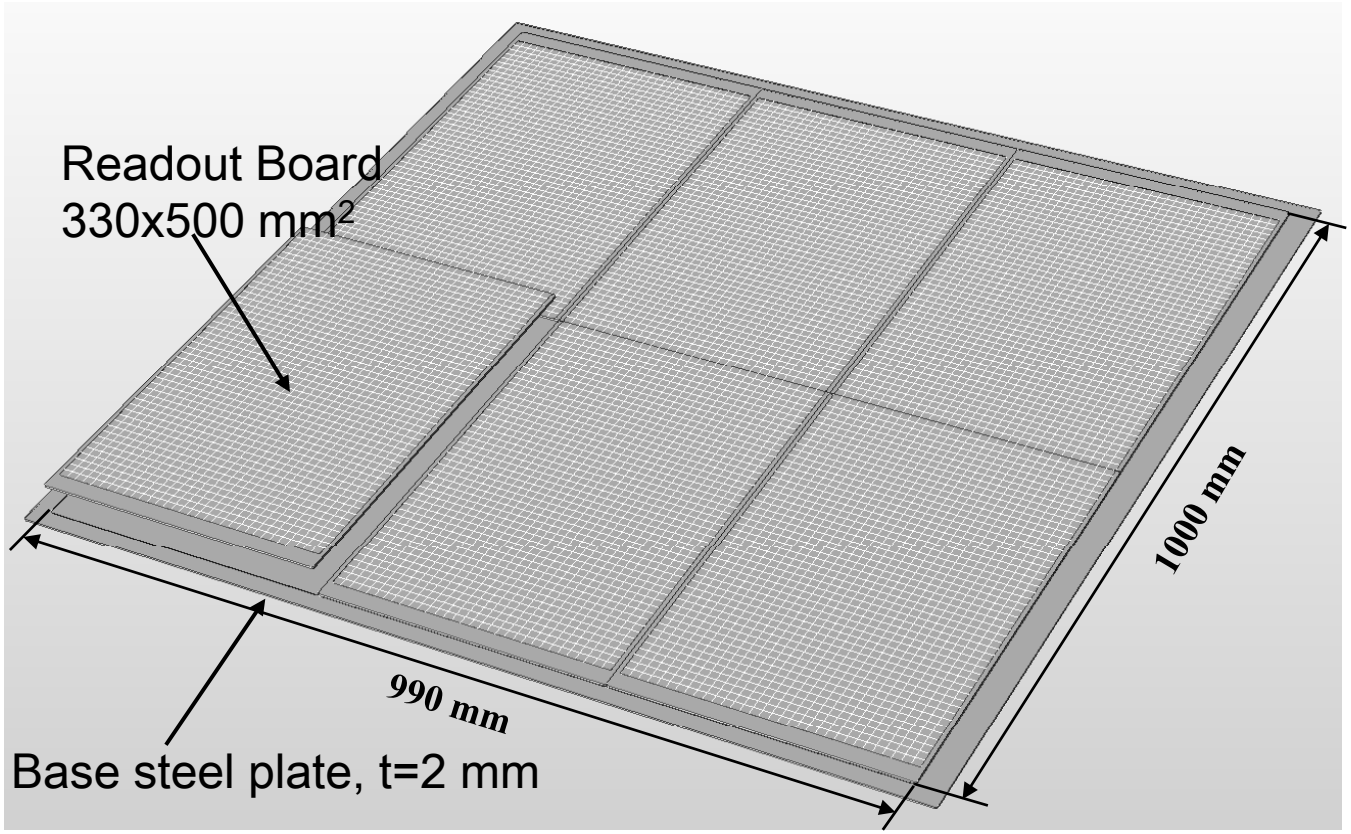


PAD

Alice HMPID cell made of 2 PCBs
-Hermetic by design
-Special NI/AU and polishing for CSI deposition
-Front end electronics in the back
- Max size : 600 x 500 per board

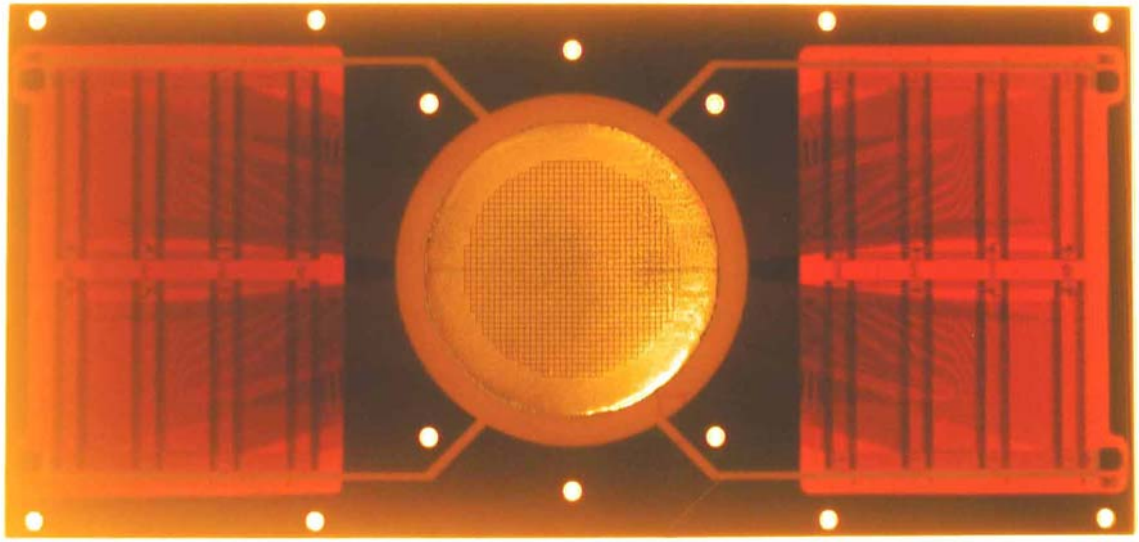




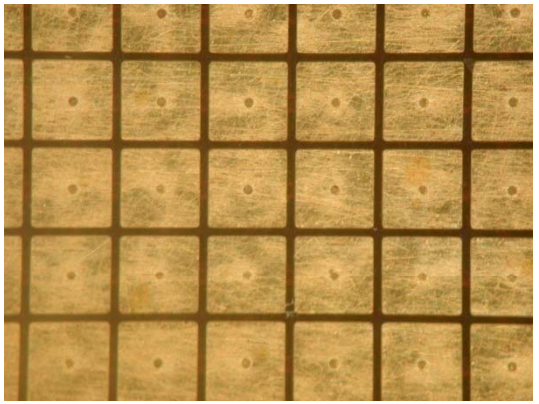


Example of sharing for larger read out board

Pixel



1024 pads on a diameter of 35mm
8 layer PCB
INFN PISA GEM detector

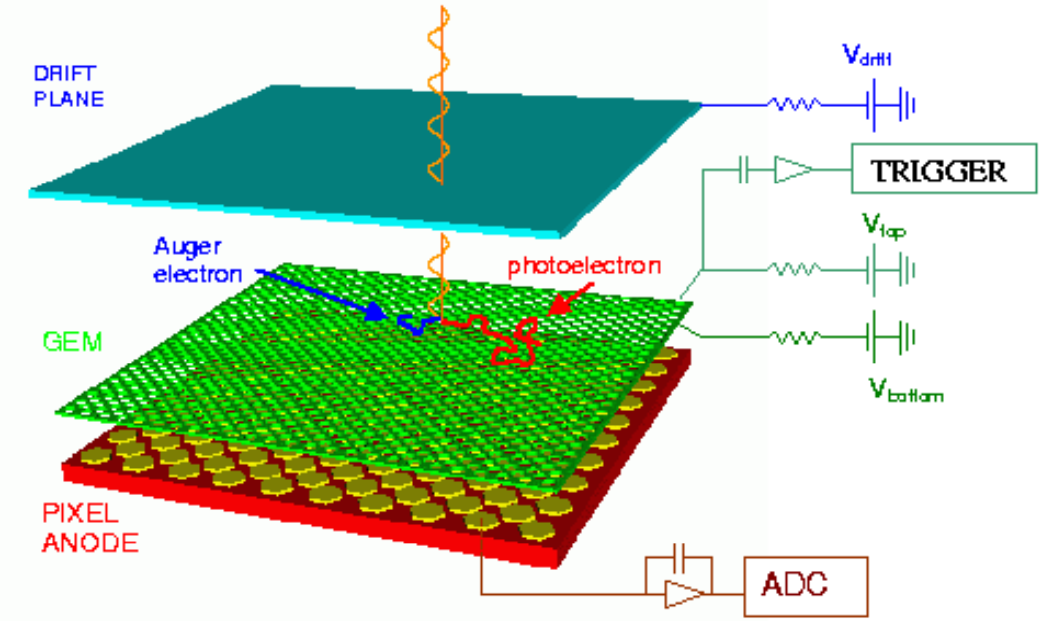


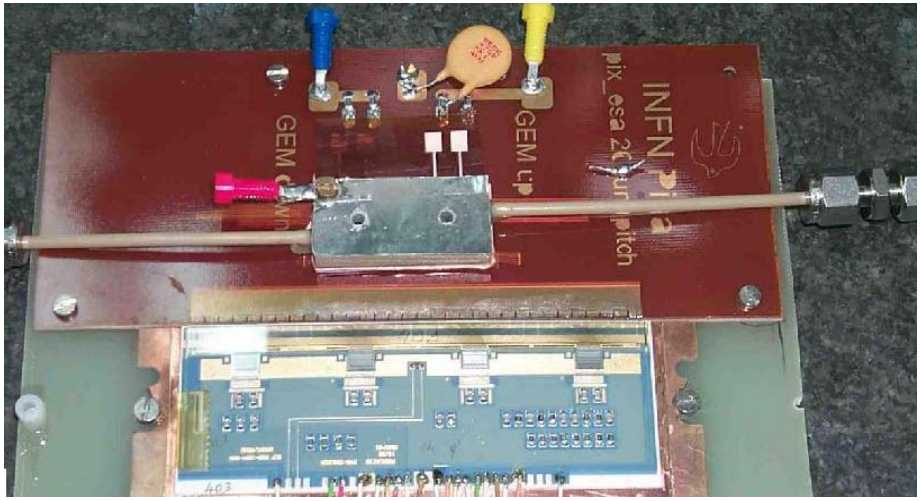
Close-up view
Pad : 1mm
Pitch : 1.05mm

Biggest problems:
-Line width
-layer count

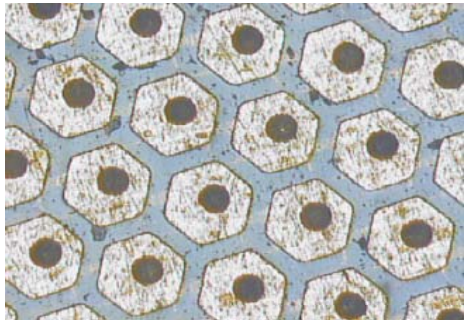
Limitations:
- 600mm x 450mm Process
- Density of connections 3cm x 3cm

Pixel read-out: an example, the PCB approach





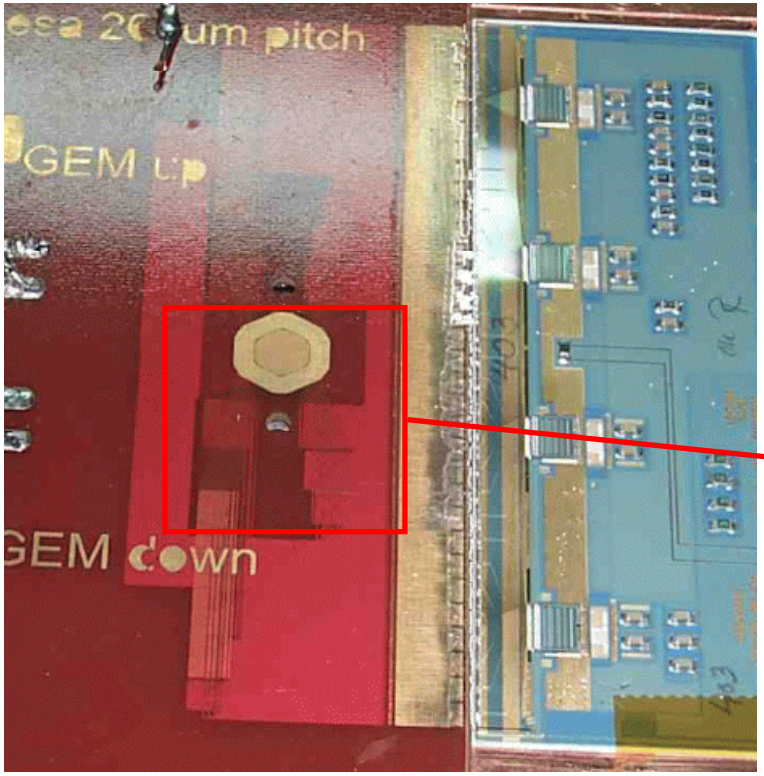
Read out plane



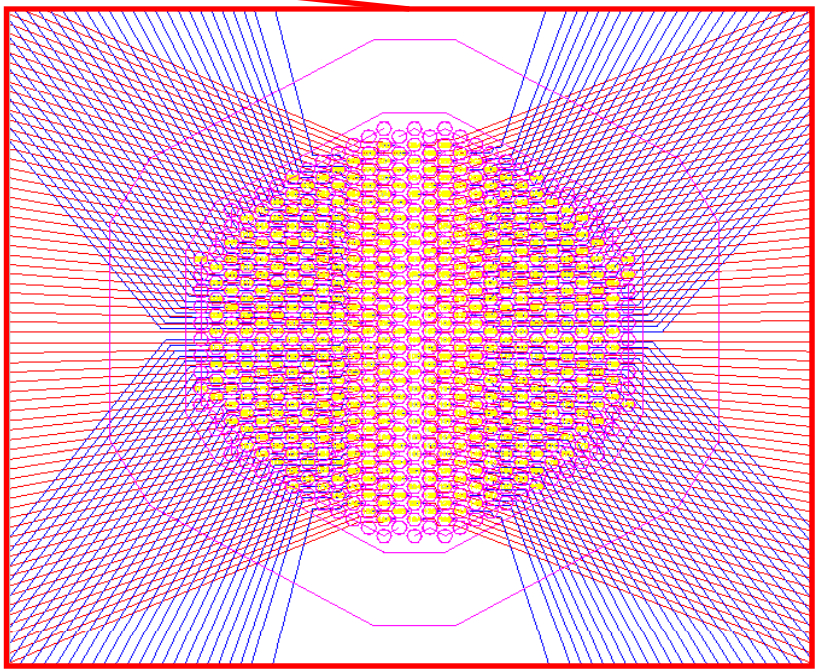
- Read out pitch: 260 μm

512 electronic channels from a few mm^2 active area are individually read out by means of a multi-layer PCB fan out

PCB approach



- 6 layers SBU (sequential build up) with 40um microvias.
- Minimum track width and space 40um

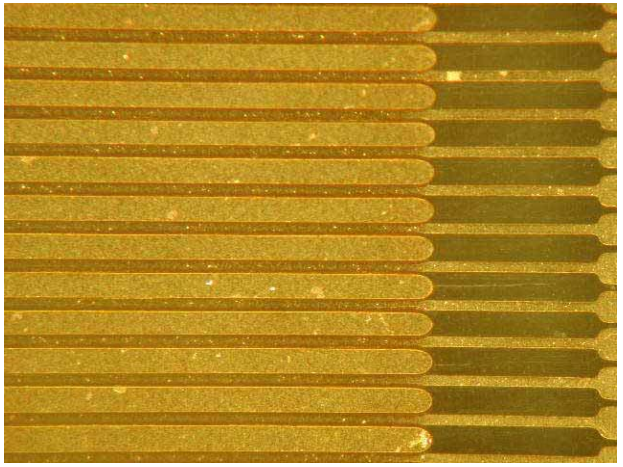


• Crosstalk between adjacent channels (signals traveling close to each other for several cm).
• Not negligible noise (high input capacitance to the preamplifiers).

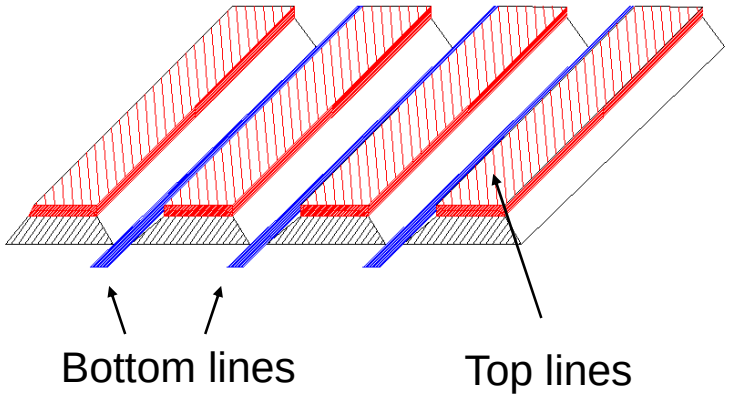
ACTIVE read-out

Micro-groove

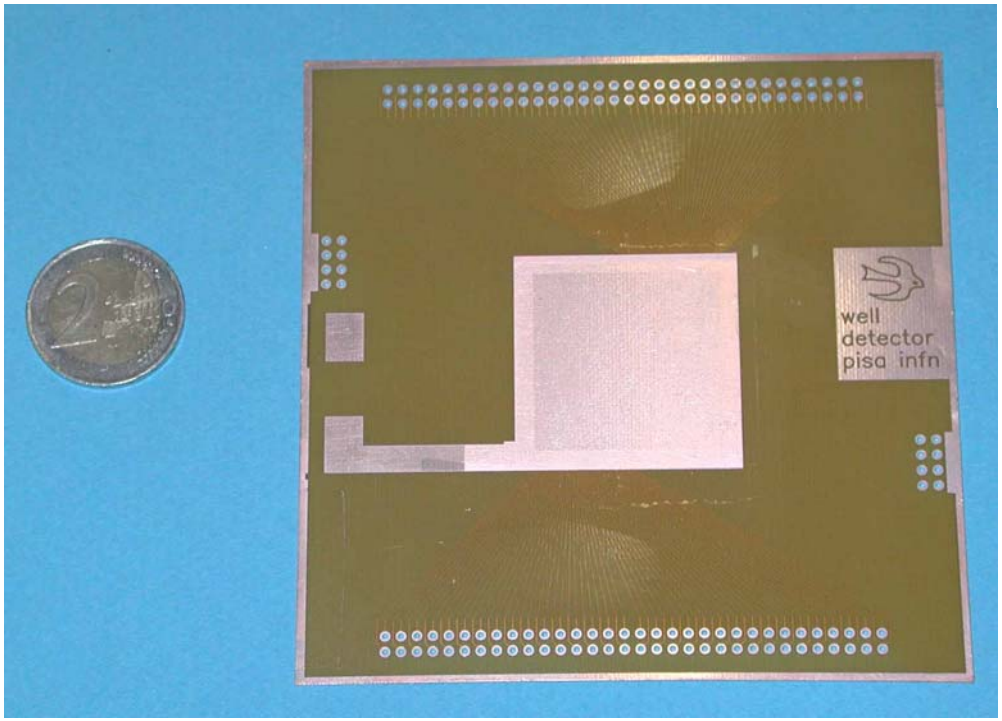
12 x 10cm groove detector
Close to a MSGC
INFN PISA/CERN

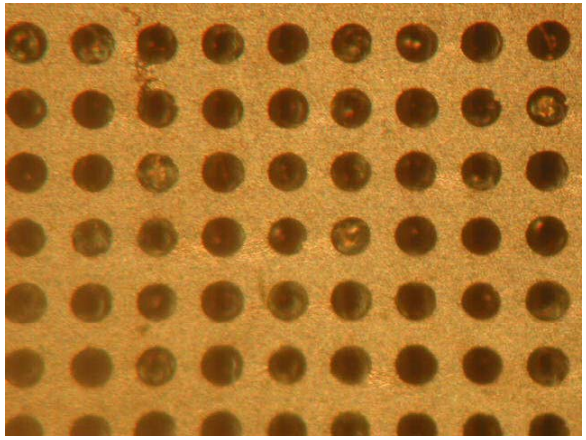


Close-up view



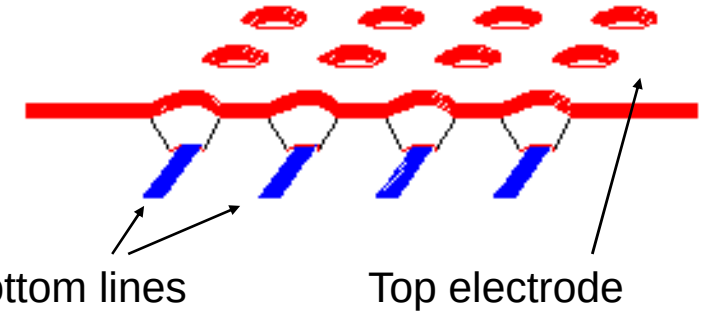
Micro-well





Close-up view

3 x 3 cm well detector
a GEM glued to the read out?
INFN PISA/ CERN



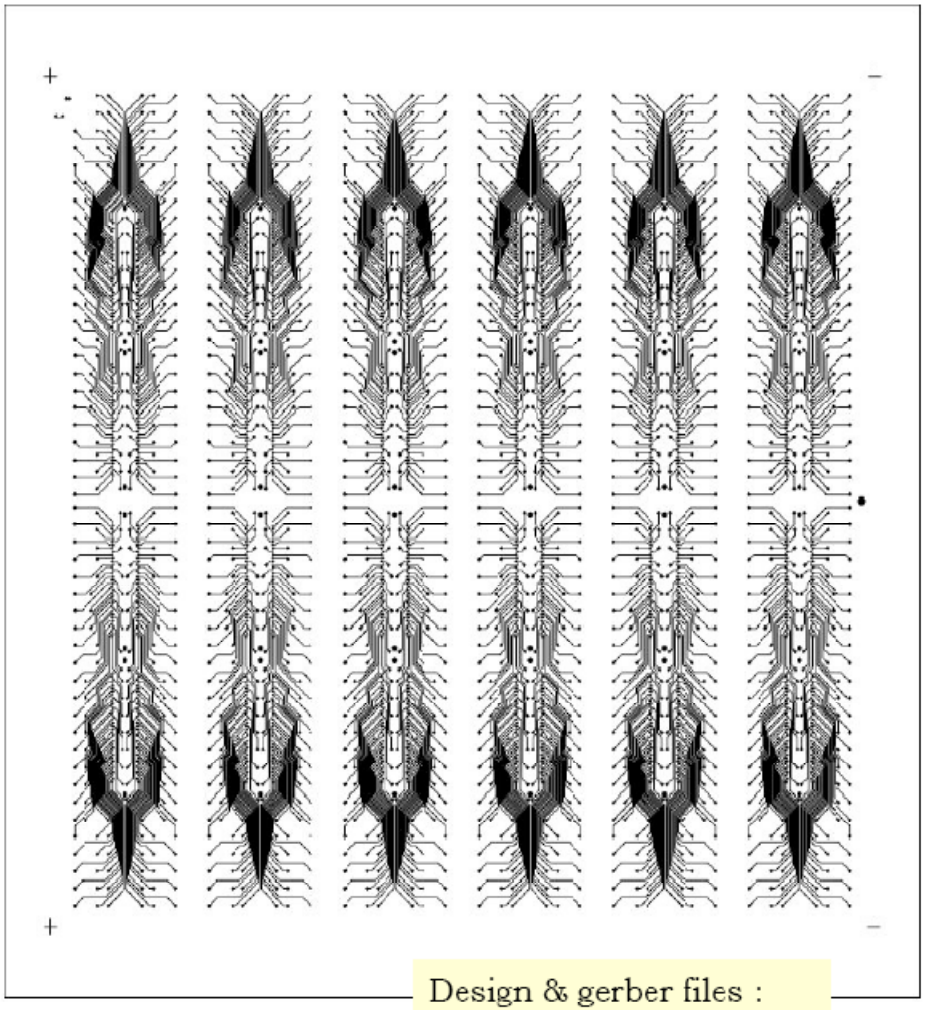
Micromegas Bulk and Micro-Bulk

T2K experiment , 84 Modules in production at CERN

Grounding and capacitive couplings

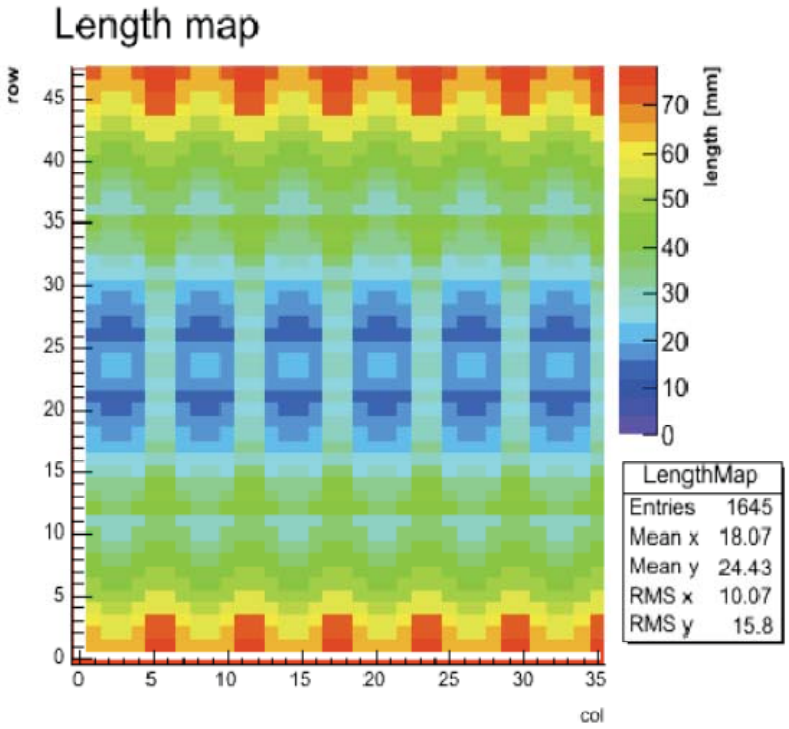
any effect?
One example

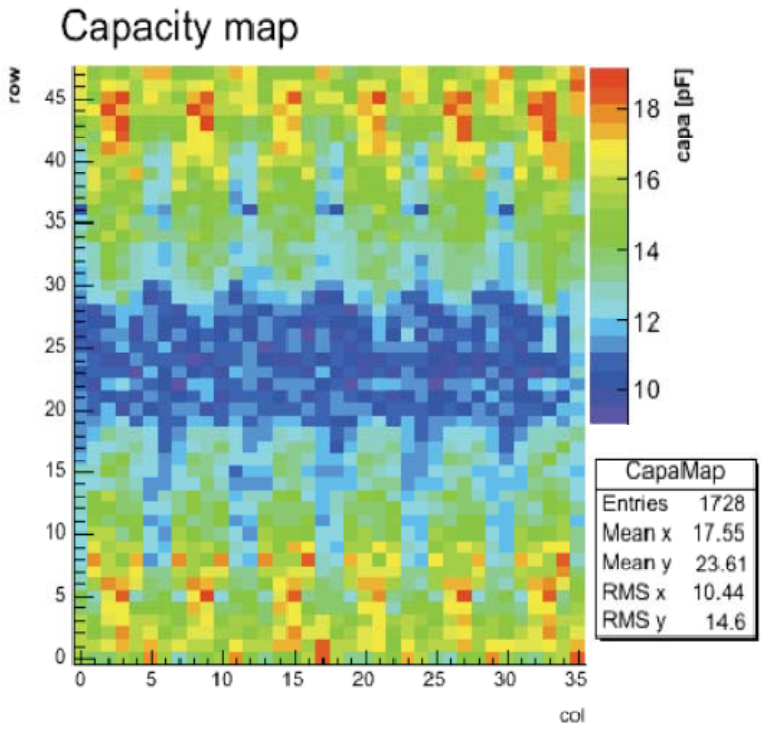
T2K bulk detector Inner layer



Design & gerber files :
M. Sanchez / S. Baiteche
CERN-TS-DEM

MM1-001 results: *Capacity correction*

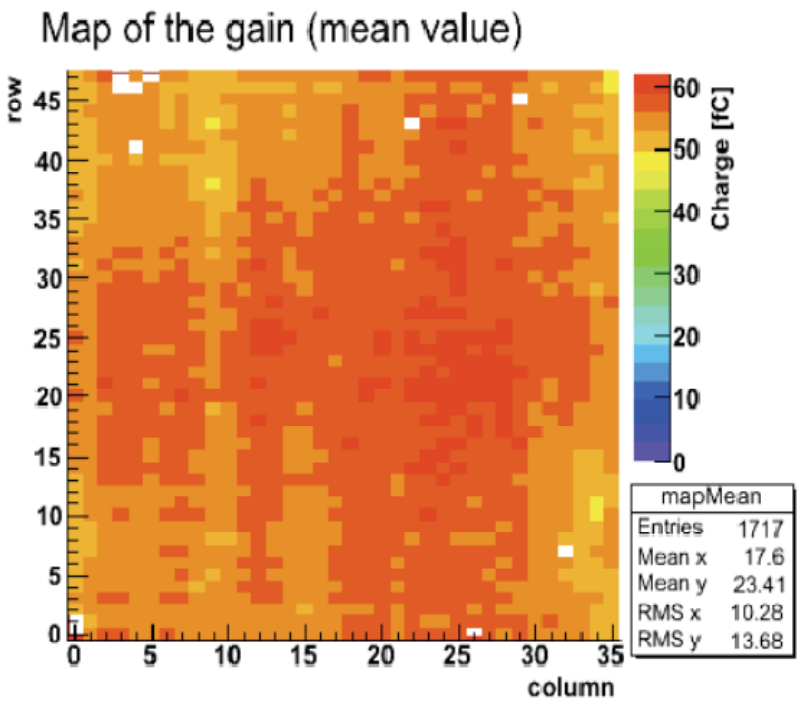


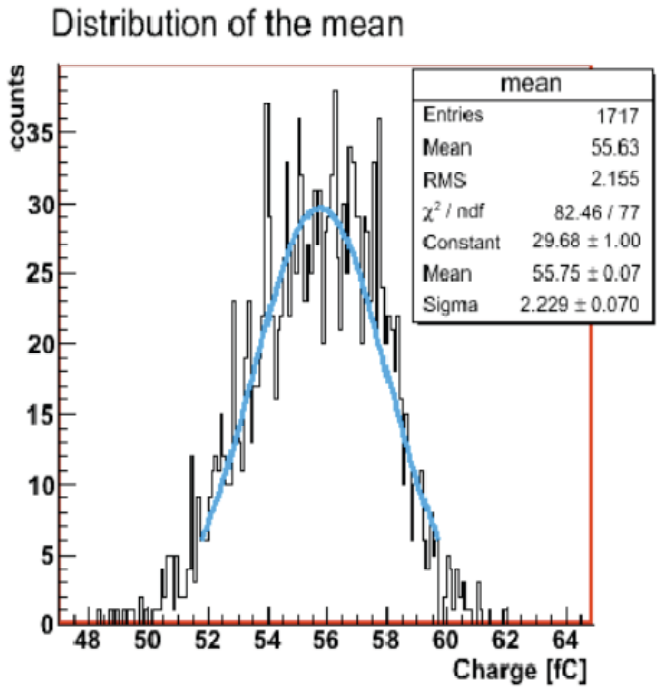


Capacitance depends on length of connecting lines
Capacitance changes gain

MM1-001 results: *Gain*

Gain variation: 4%





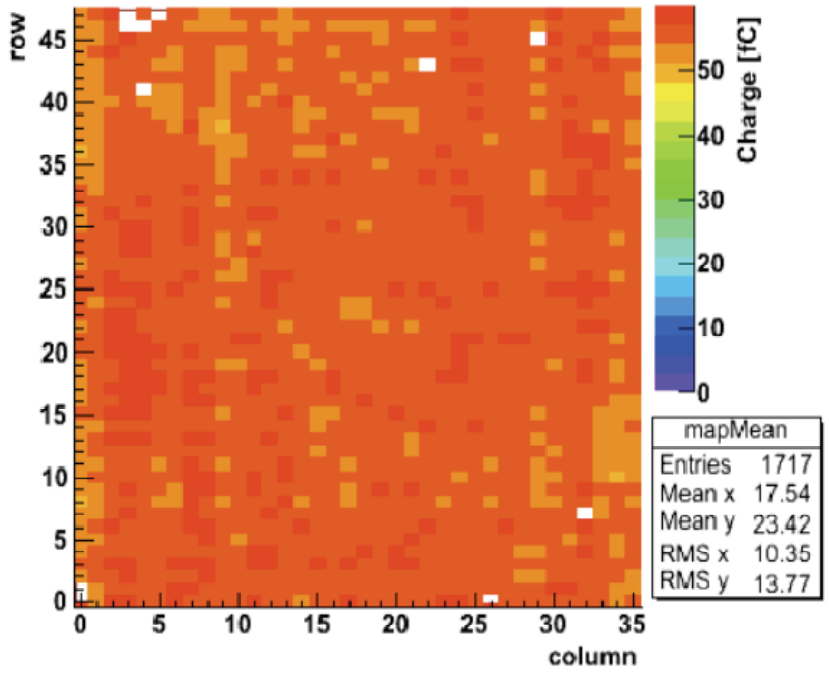
MM1-001 results: *Gain corrected*

$$G_{corr} = \frac{G_i}{G_{fec}(x)} \times G_{moy}(14)$$

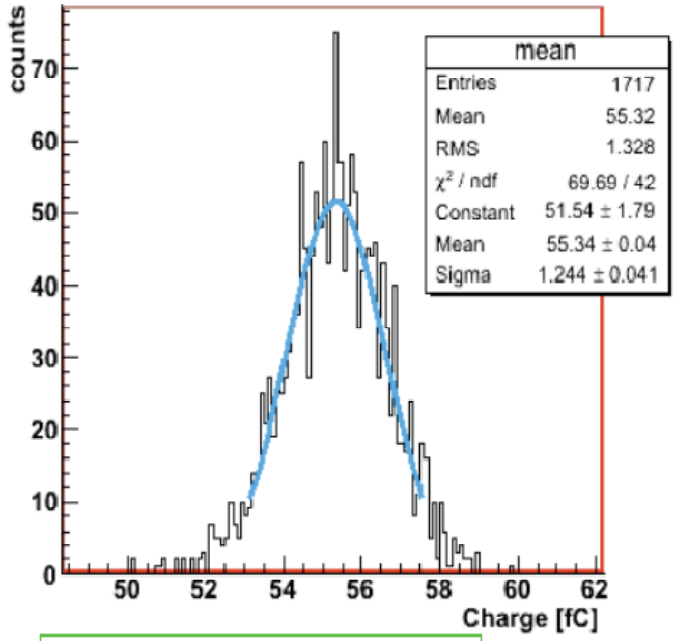
Very high precision when corrected for capacitance

Gain variation: 2.2%

Map of the gain (mean value)

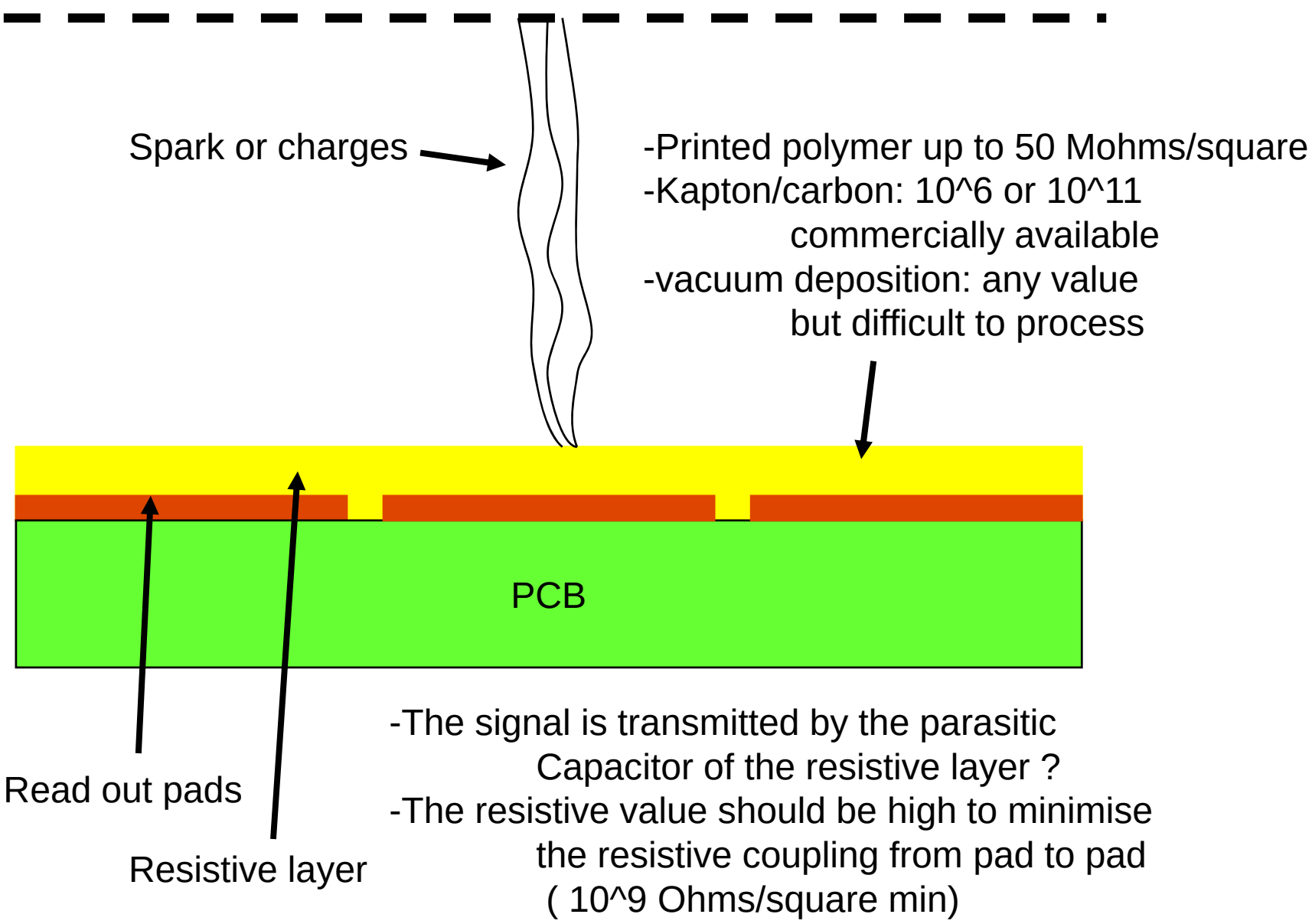


Distribution of the mean

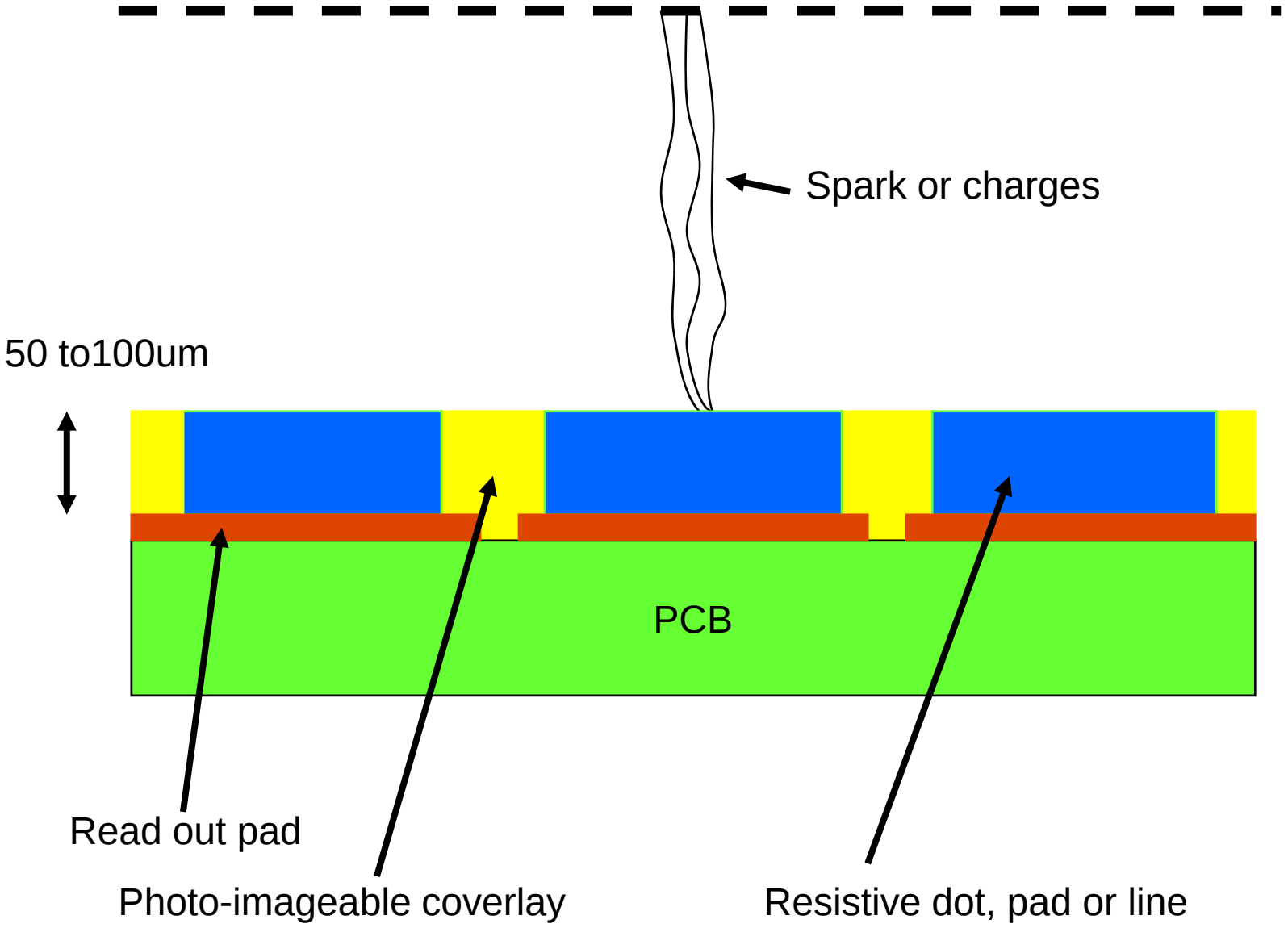


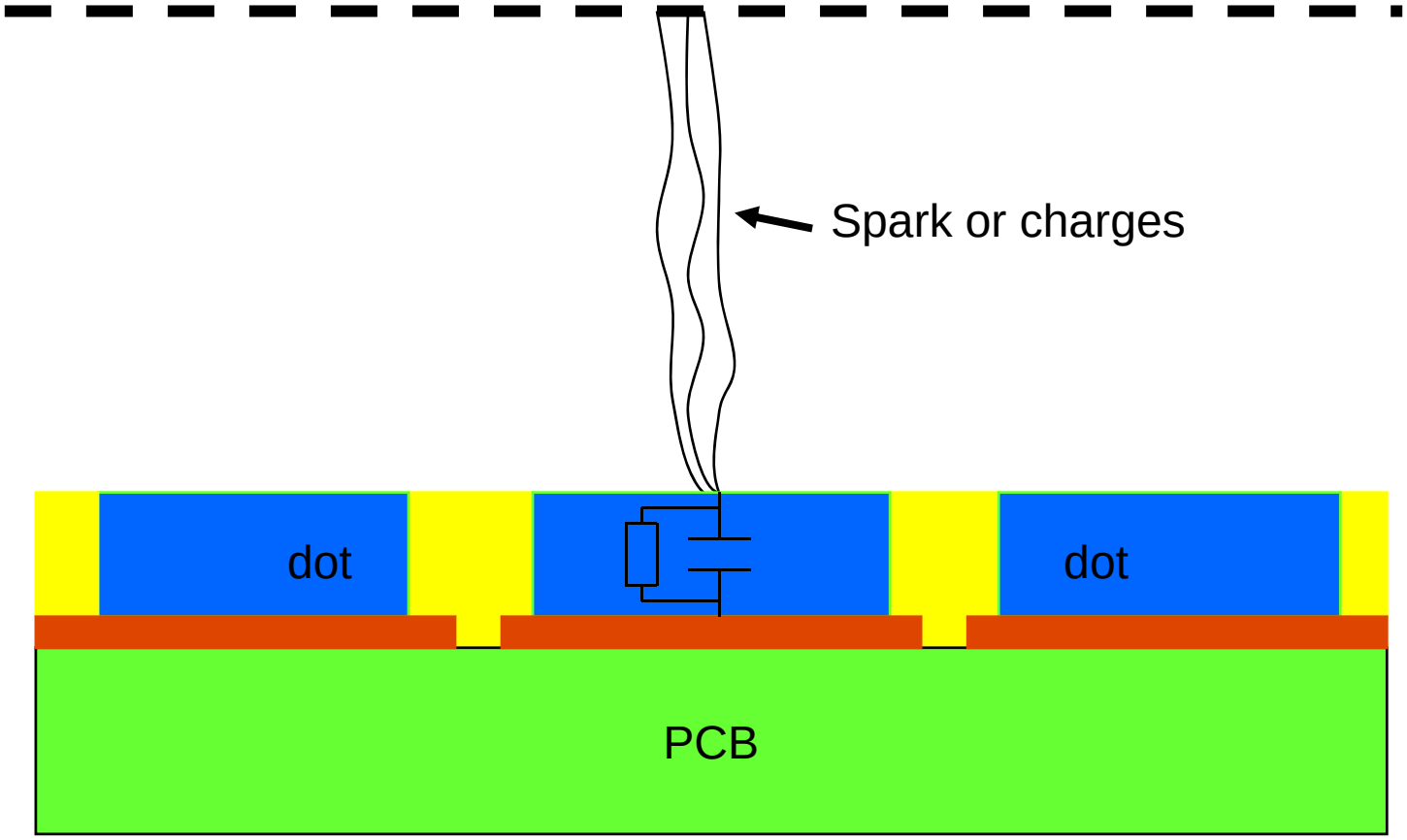
Gain: ~1550

Resistive spark protection


Spark or charges
-Printed polymer up to 50 Mohms/square
-Kapton/carbon: 10^6 or 10^11
commercially available
-vacuum deposition: any value
but difficult to process
PCB
Read out pads
Resistive layer
-The signal is transmitted by the parasitic
Capacitor of the resistive layer ?
-The resistive value should be high to minimise
the resistive coupling from pad to pad
(10^9 Ohms/square min)

How to avoid the resistive coupling from pad to pad

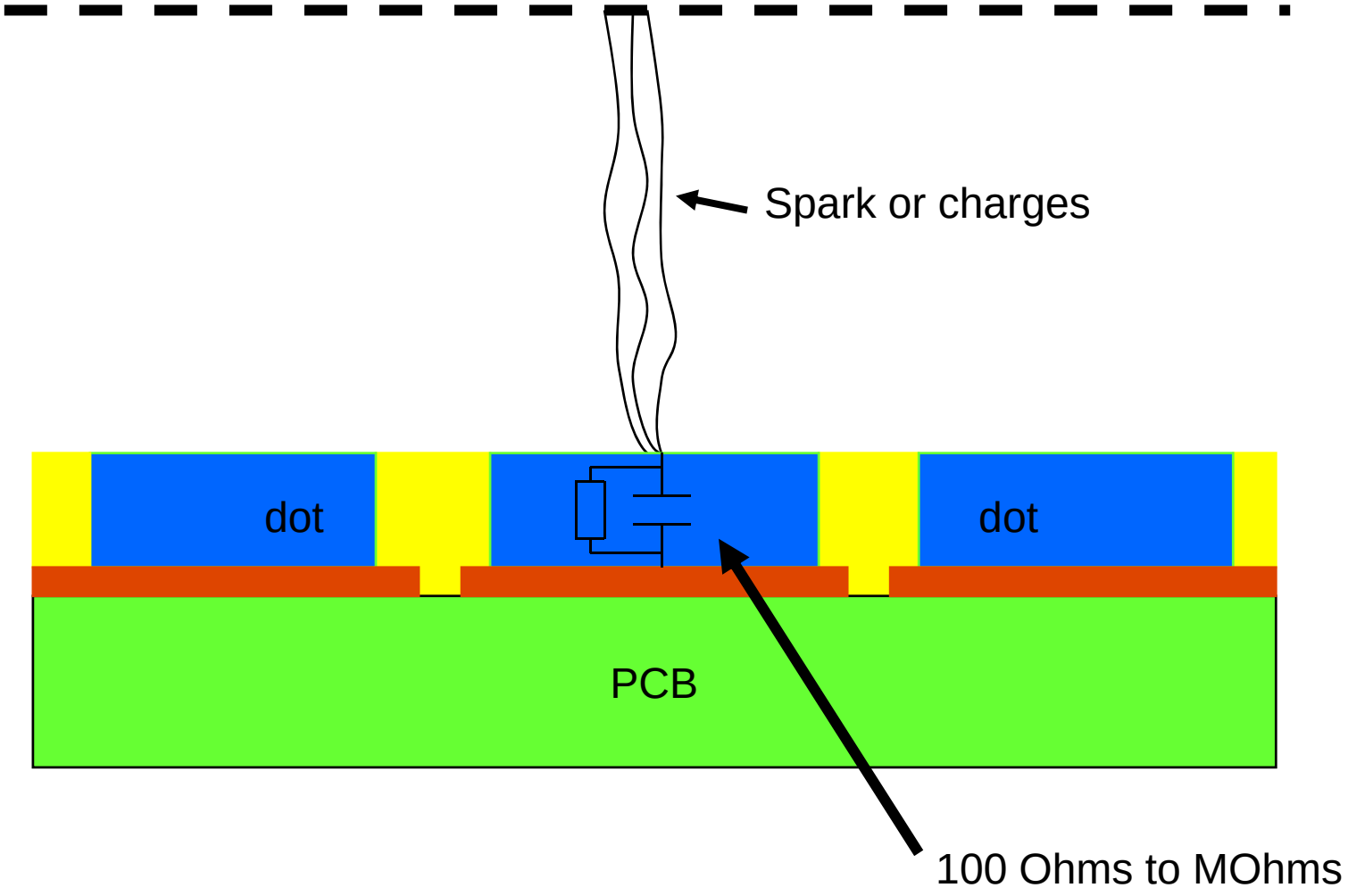


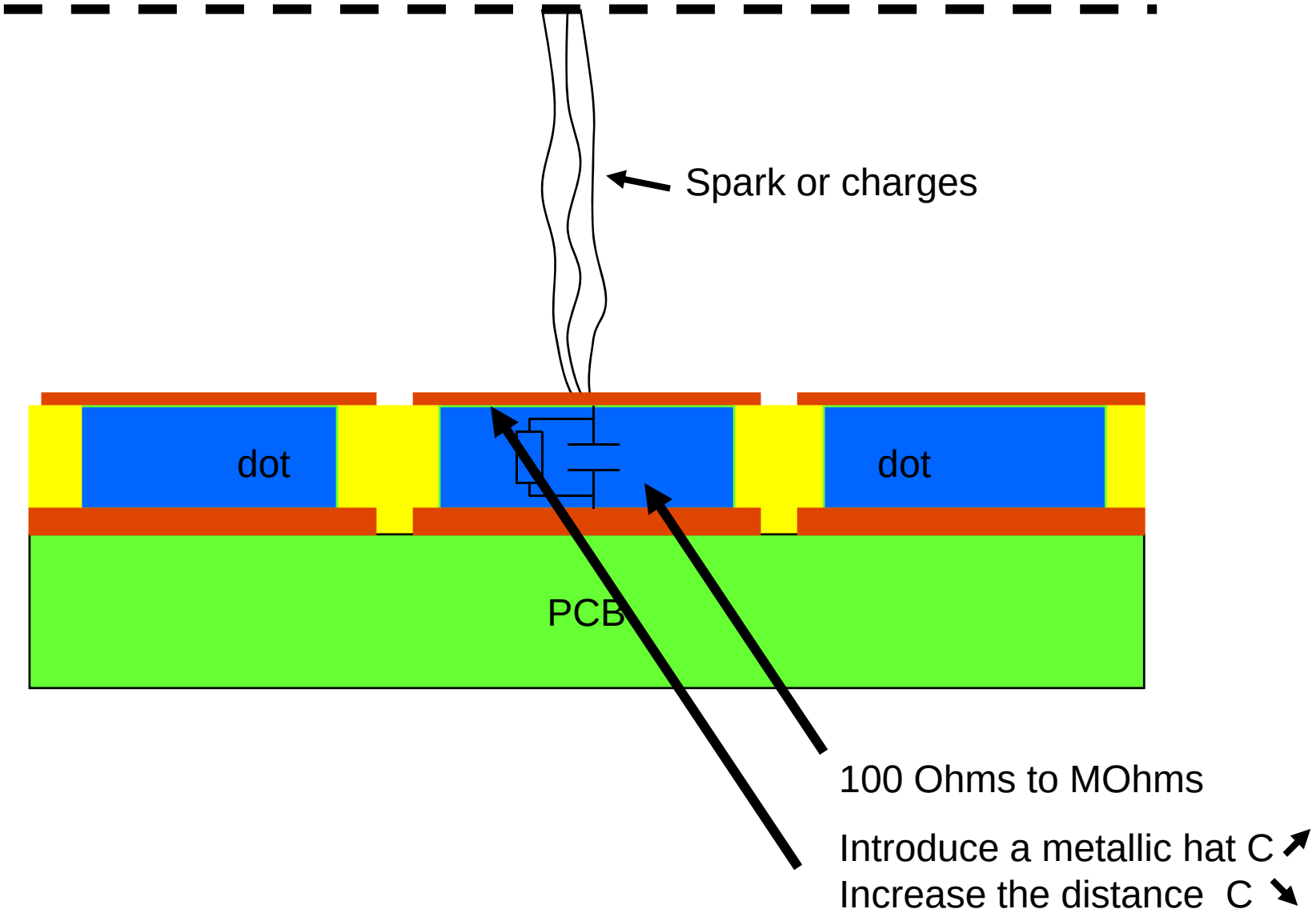


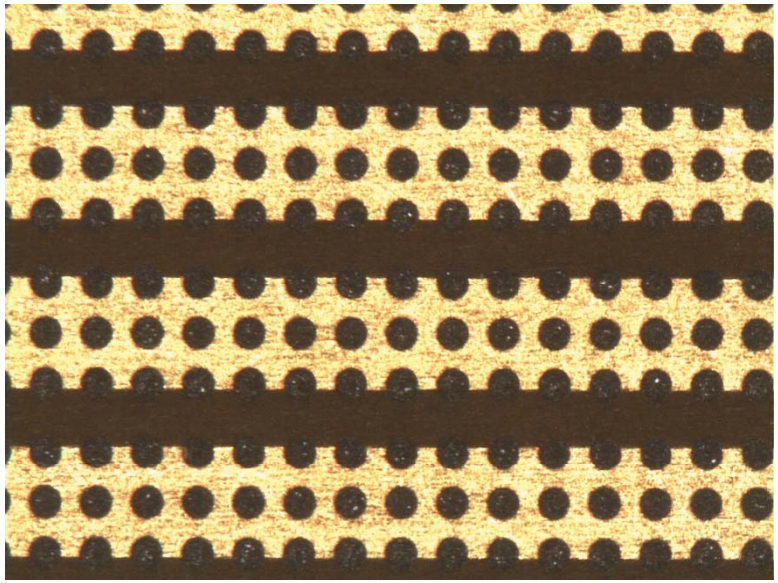
R: Serial resistor limiting max current
- High enough to limit energy of spark ?
- Low enough to remove charges

C: Serial parasitic capacitor High pass filter
- High enough to transfert signal charges
- Dielectric quality--> spark protection?

C or R doing spark protection ?


Spark or charges
dot
dot
PCB
100 Ohms to MOhms


Spark or charges
dot
dot
PCB
100 Ohms to MOhms
Introduce a metallic hat C ↗
Increase the distance C ↘

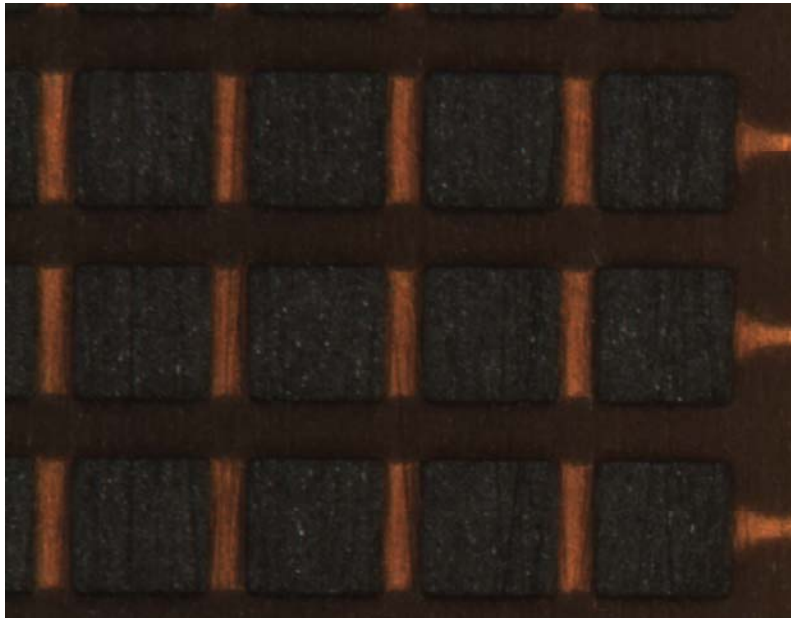


Dot architecture

-Min : 0.15mm diameter

-Pitch: 0.25mm

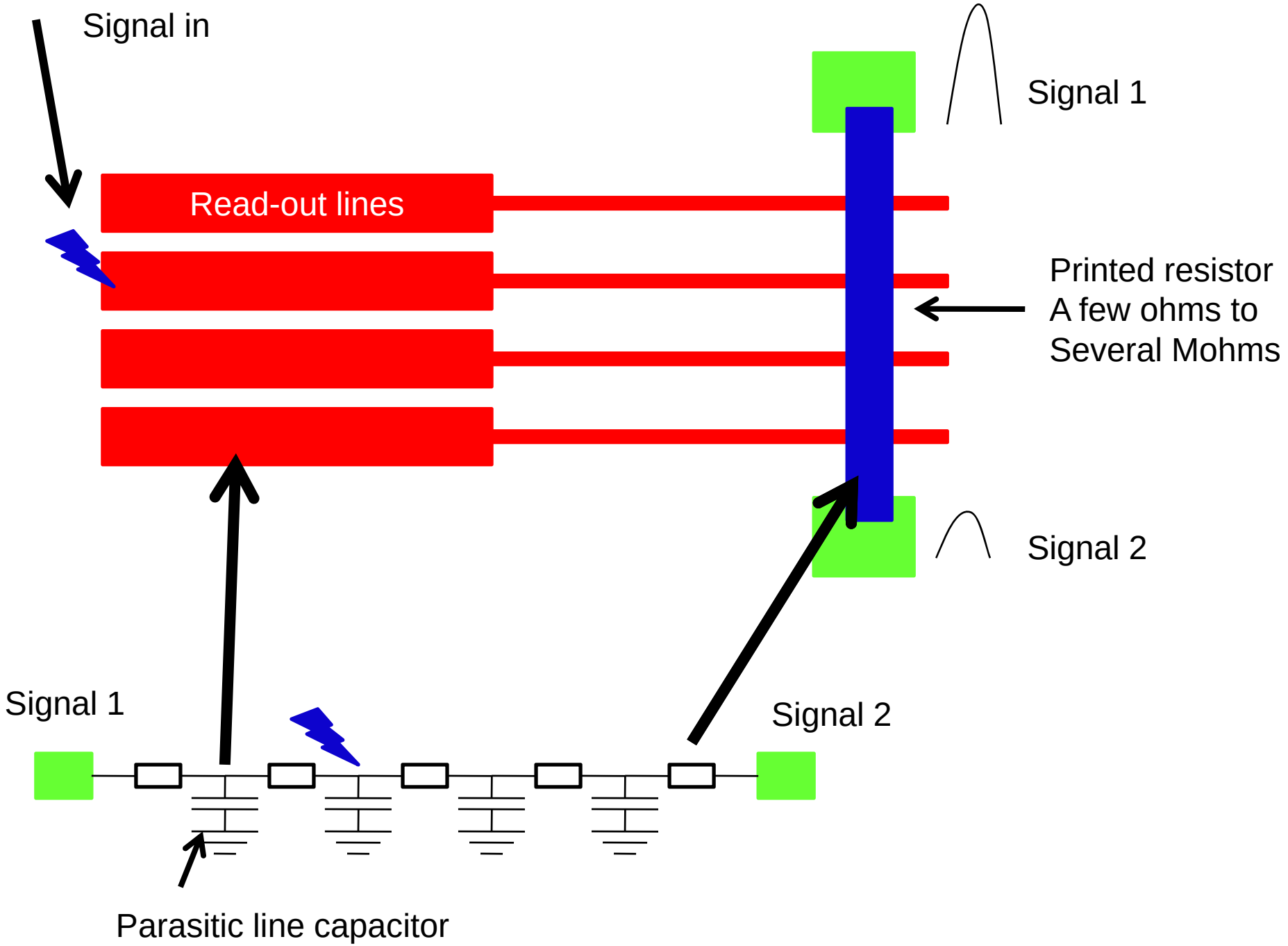
-Possibility to avoid alignment between track and dots

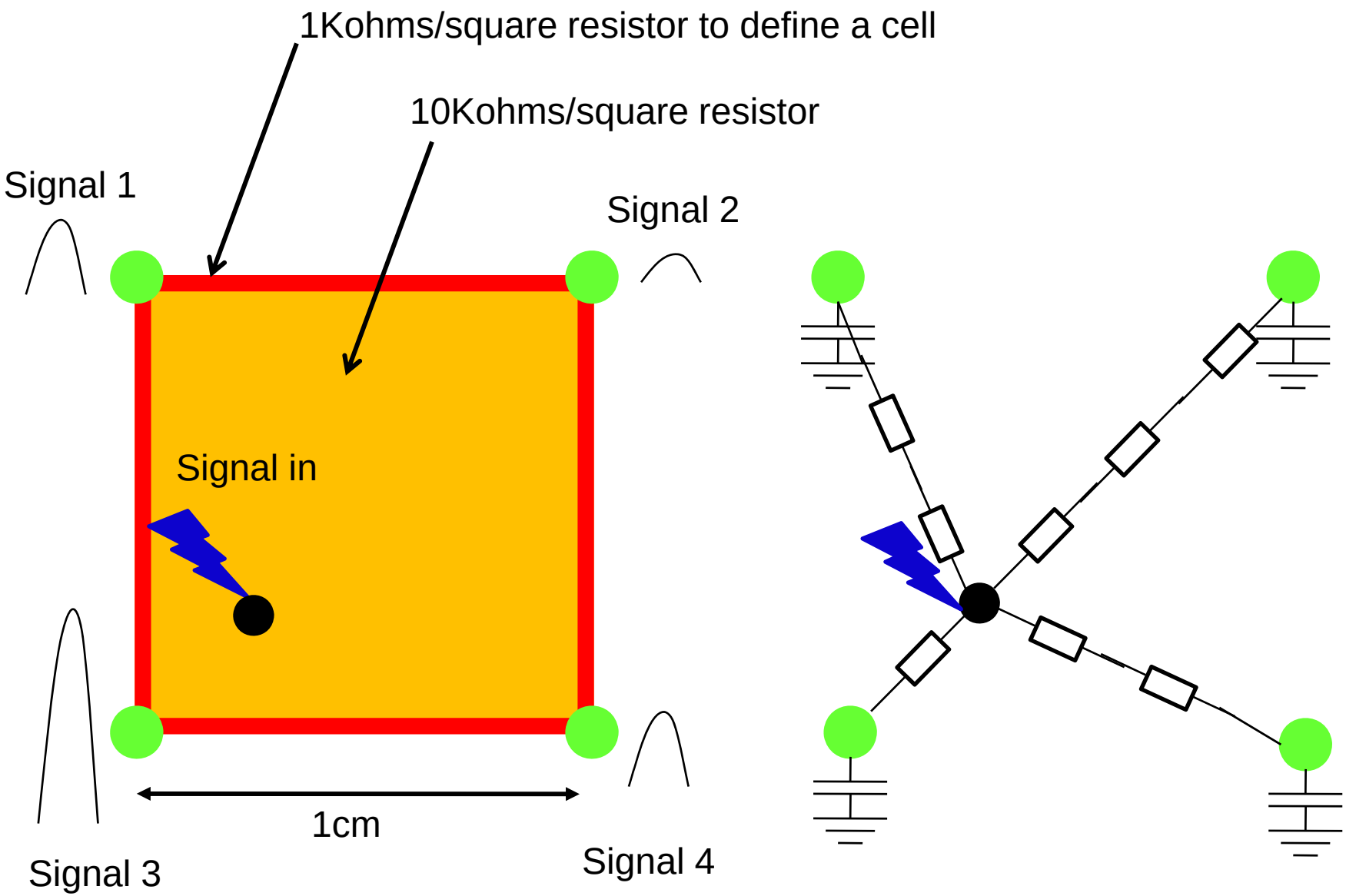


Pad architecture

-needs alignment

Resistive spreading


Signal in
Signal 1
Read-out lines
Printed resistor
A few ohms to
Several Mohms
Signal 2
Signal 1
Signal 2
Parasitic line capacitor



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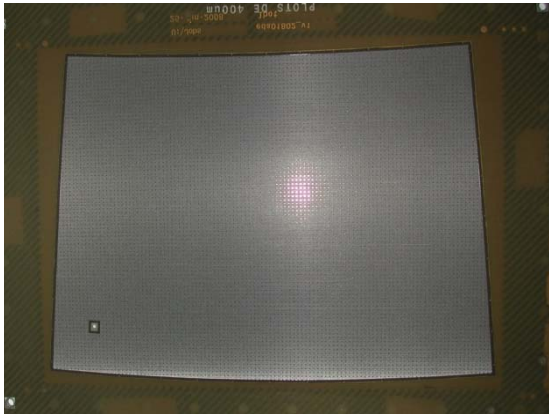
Copper

Prepreg defining the capacitor dielectric

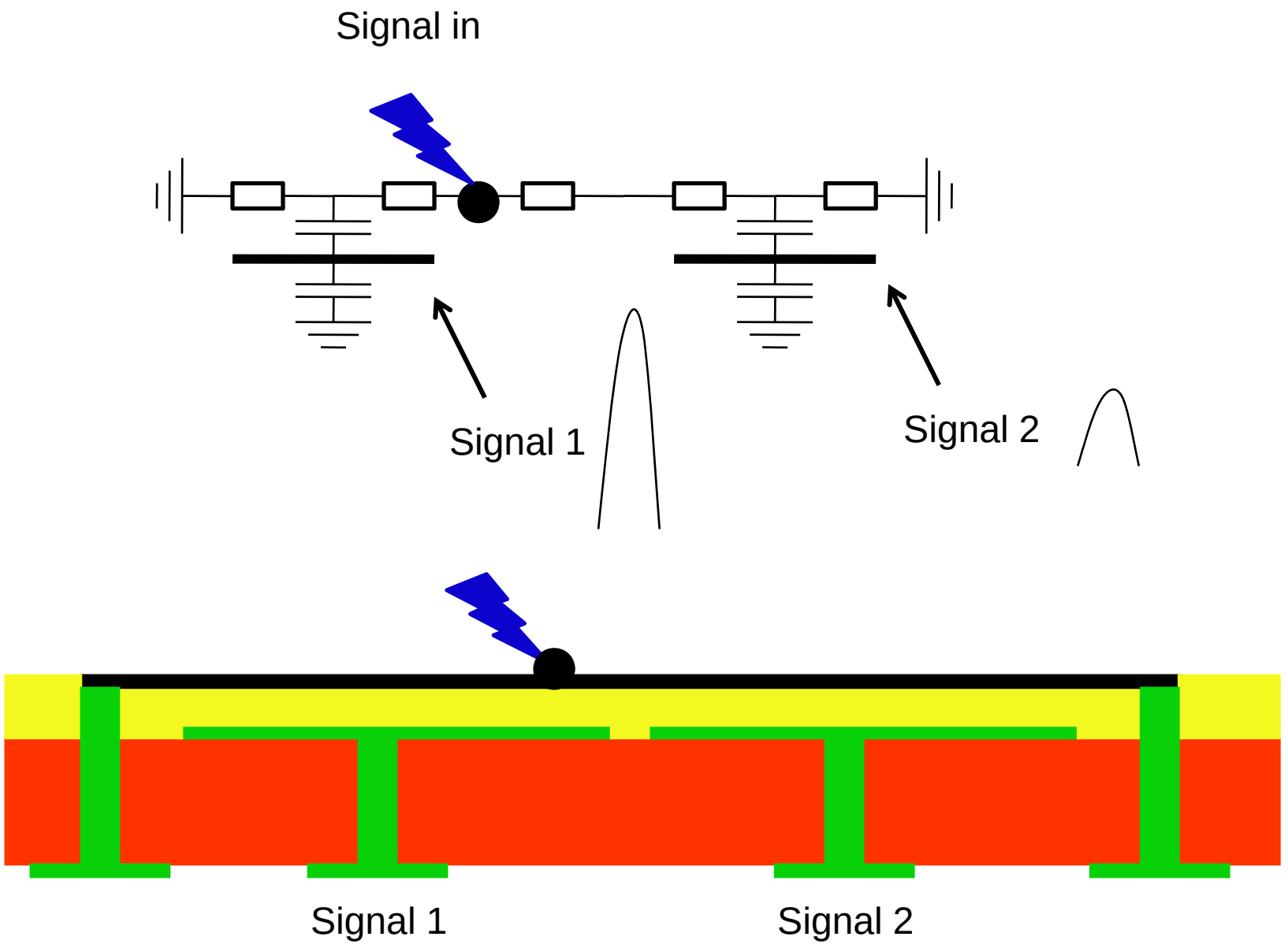
FR4

resistive layer for charge spreading

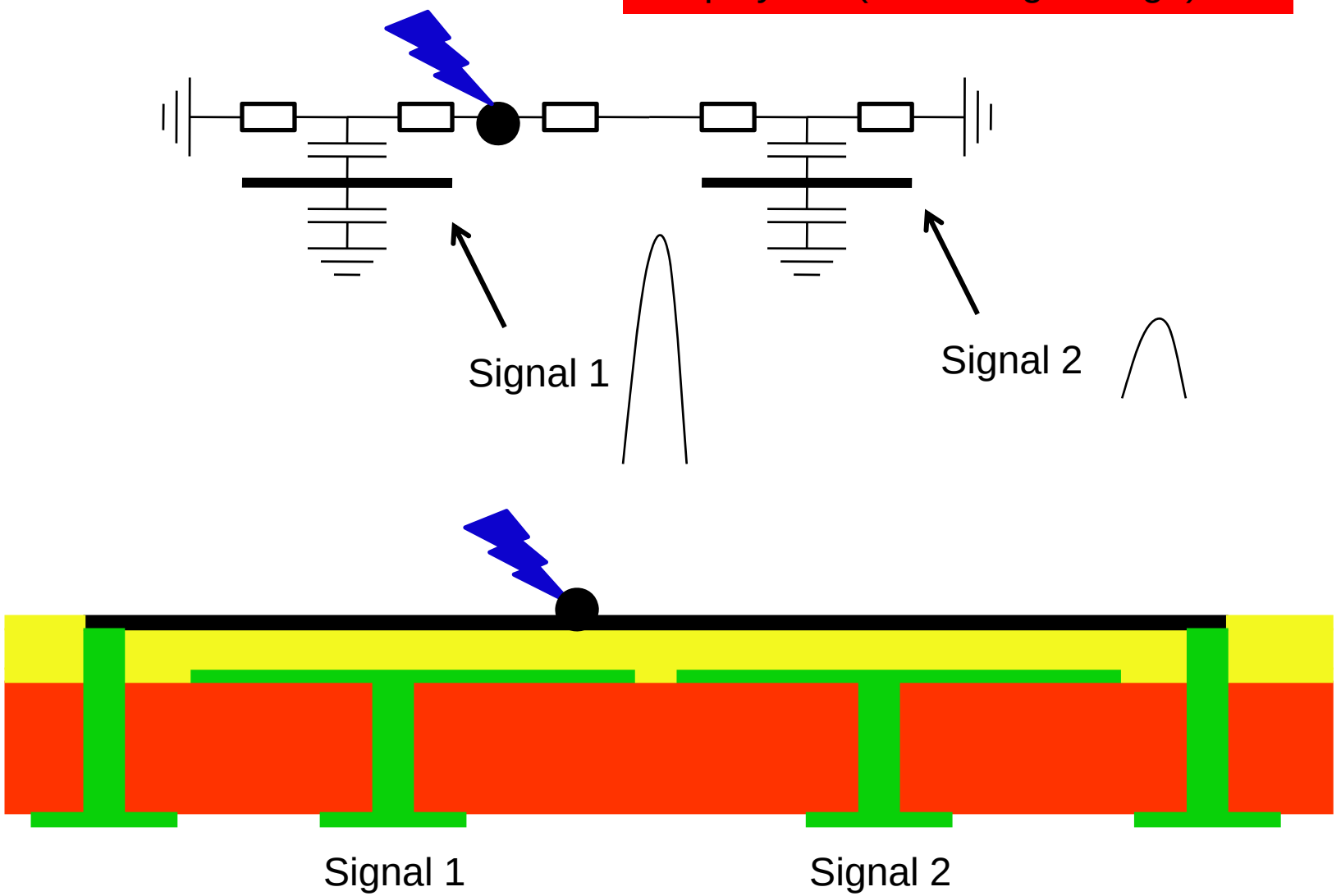


200mm x 150mm
Bulk micromegas with
Resistive spreading

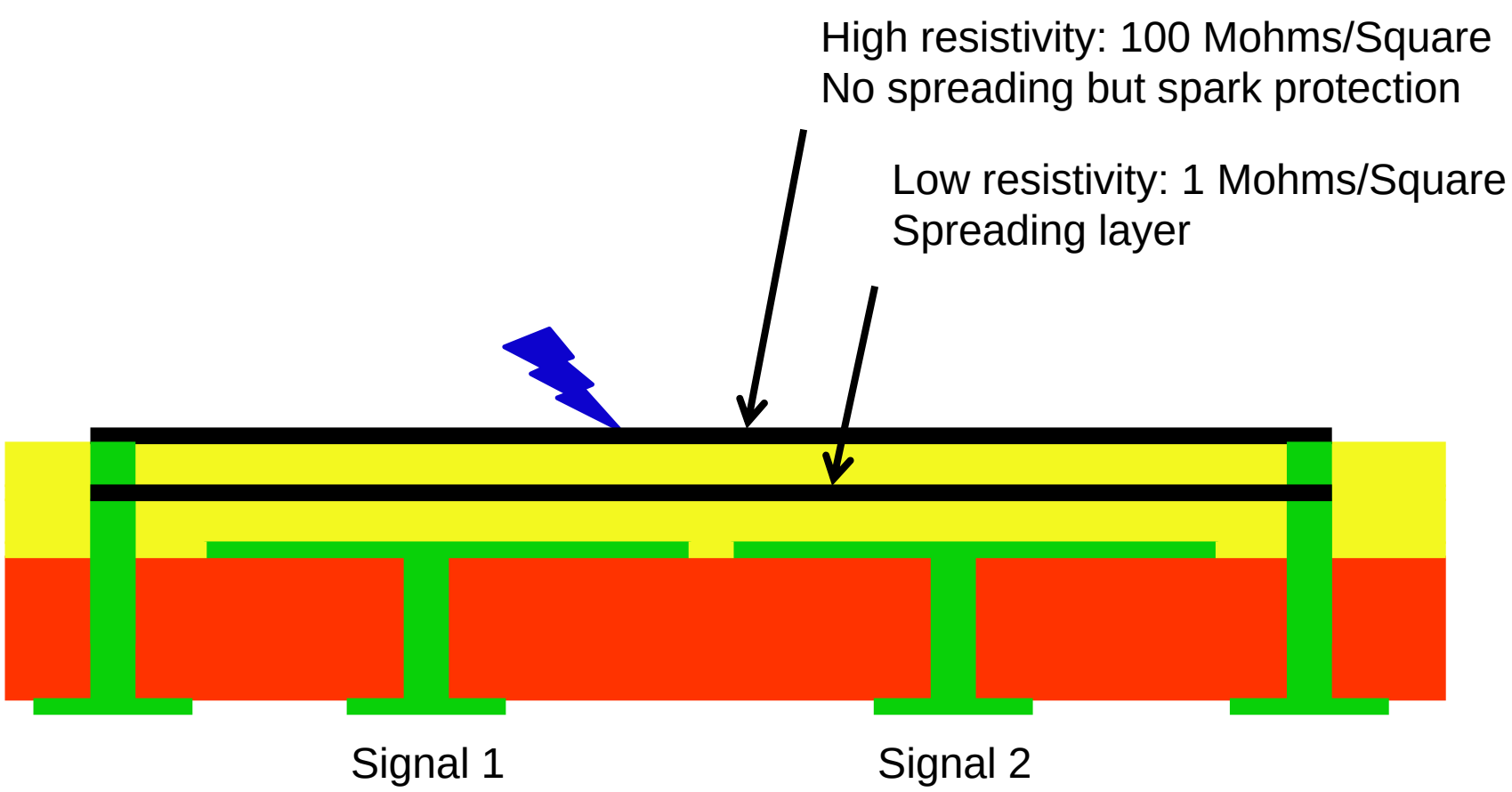
For details contact Paul Colas


Signal in
Signal 1
Signal 2
Signal 1
Signal 2

Spreading seems OK but still some problems created by sparks due to the polymer (not strong enough)



?


High resistivity: 100 Mohms/Square
No spreading but spark protection
Low resistivity: 1 Mohms/Square
Spreading layer
Signal 1
Signal 2

Copper

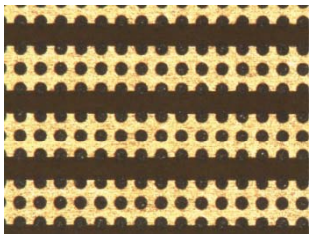
Imageable coverlay

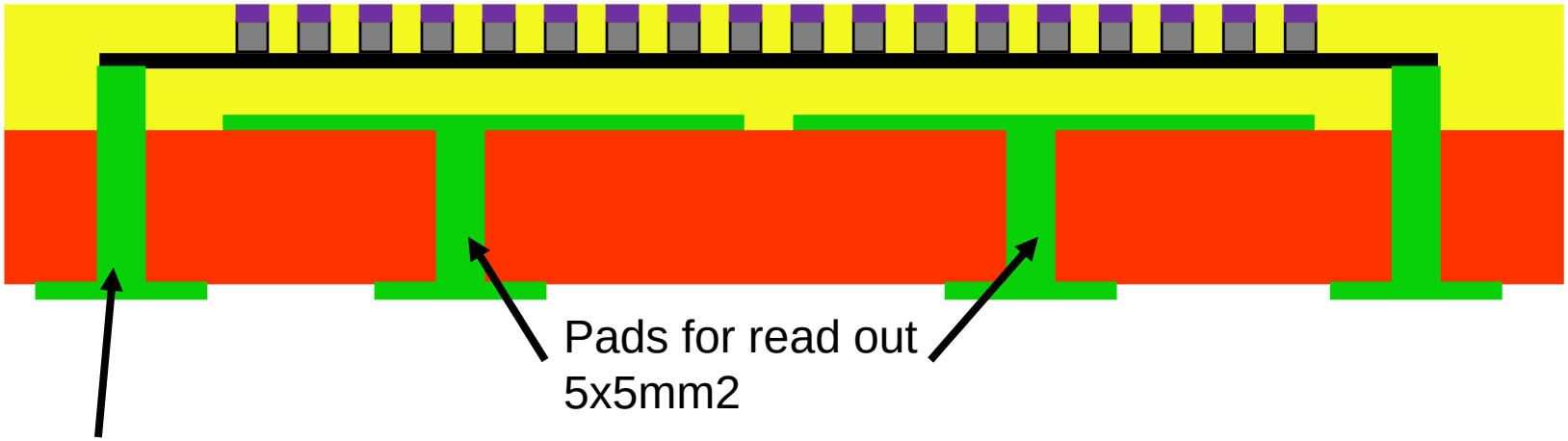
FR4

resistive layer for charge spreading

resistor for spark protection

Copper to define input capacitor





Thank you