A real x-y Microbulk Micromegas with Segmented mesh

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The collaboration

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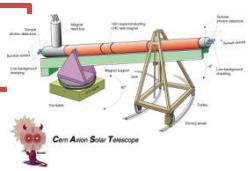
OUTLINE

- **The Micromegas evolution**
- **The segmented mesh microbulk**
- **Manufacturing and tests**
- **Results**
- **Prospects and applications**

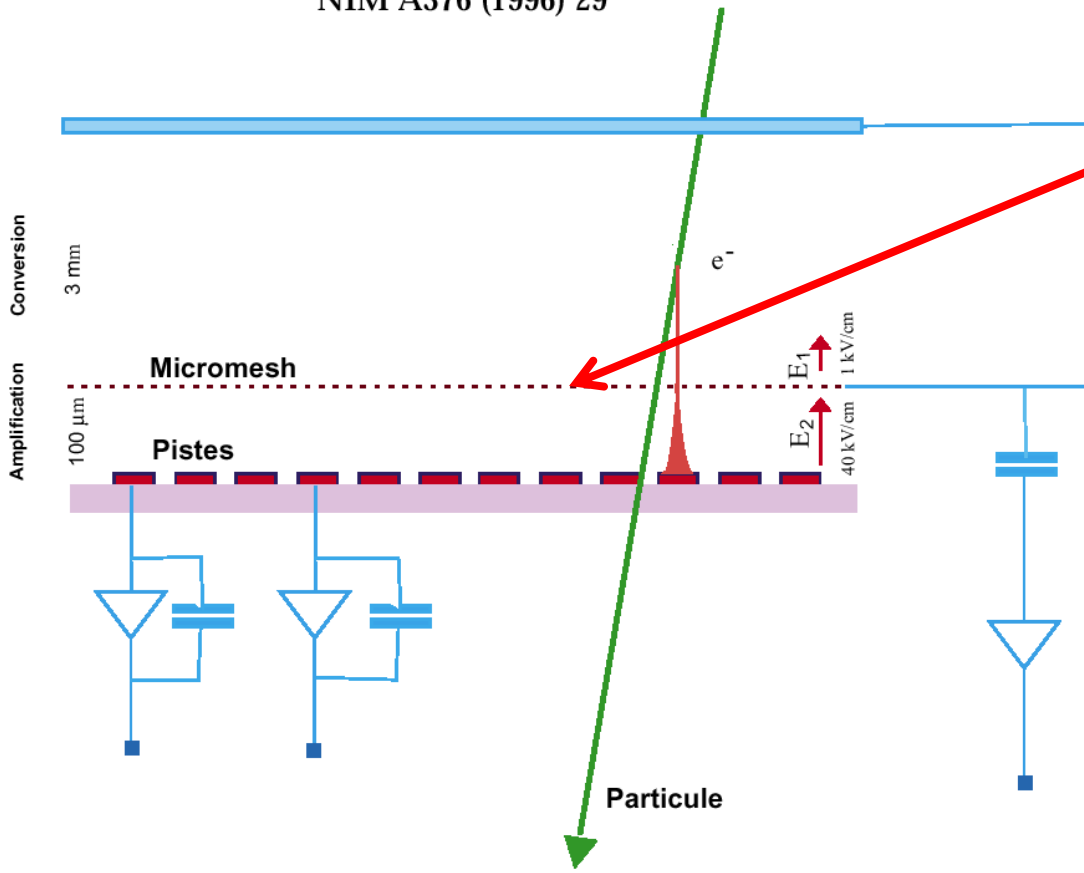
RD51 Common Fund Project

Micromegas – early days manufacturing



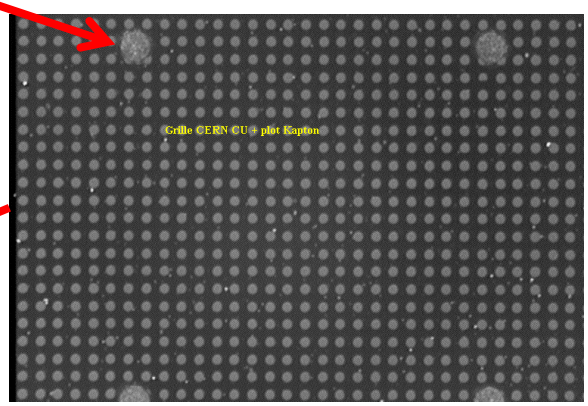
MICROMEGAS

Y.Giomataris, Ph. Rebourgeard, J.P Robert and G. Charpak
NIM A376 (1996) 29



Micromegas: MICRO MEsh GAseous Structure detector

Spacers
h=50µm



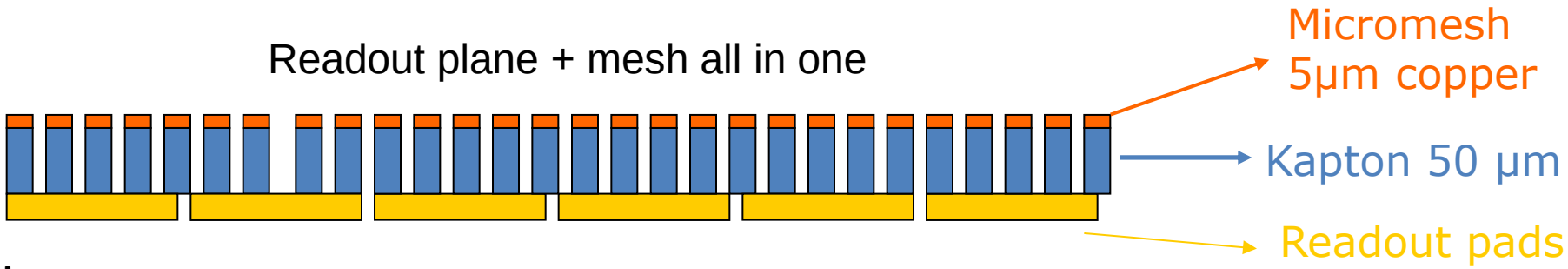
Hole diameter=50µm, pitch=100µm

Early days manufacturing

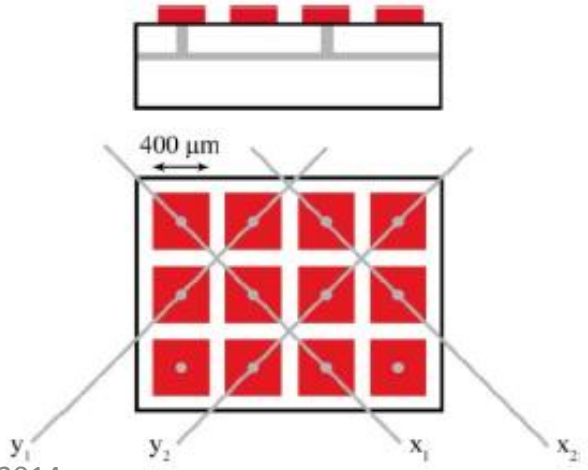
- Start with double sided copperclad pcb of 50 µm width
- Develop the mesh holes on one side
- Leave pilars only on the other side
- Stretch the produced mesh – a foil of 5 µm width with 50 µm diameter holes and pilars of 50 µm height attached to it - on top of the anode strips

Microbulk Micromegas Detectors

Microbulk MM S. Andriamonje et al., JINST 5P02001 (2010)
The pillars are constructed by chemical process of a kapton foil, that is attached to the mesh and to the readout plane



Advantages:
Uniformity, Reachable Energy resol. (<15% @ FWHM @ 5.9 keV), better long term stability
Disavantages: Complexity in manufacturing process, fragility, **complicated x – y readout**

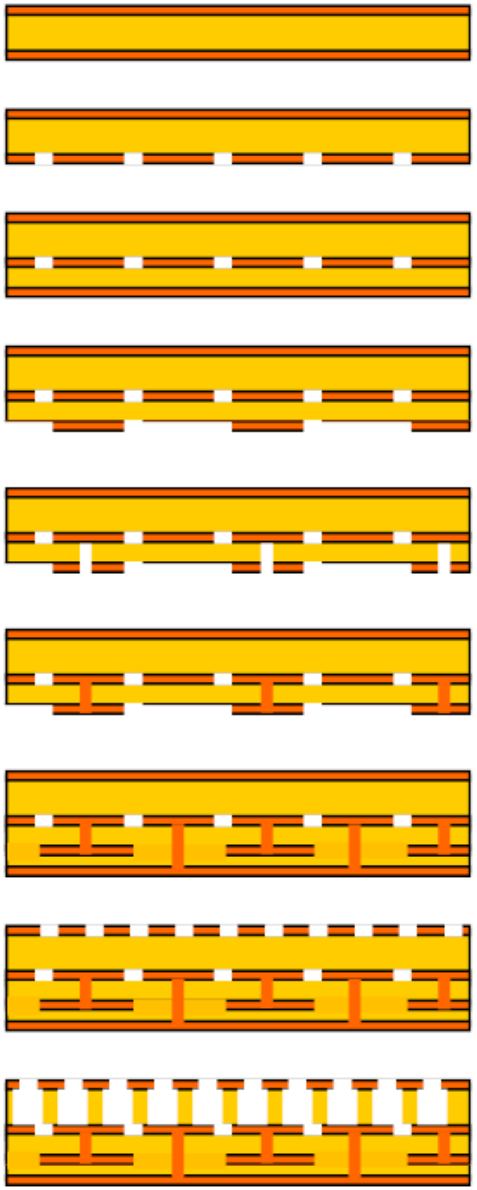


Complicated 2D Readout Schemes

- Square pads connected with vias (2 extra layers)
- Thicker detectors
- Charge disctribution in x – y is determined by the mesh hole geometry

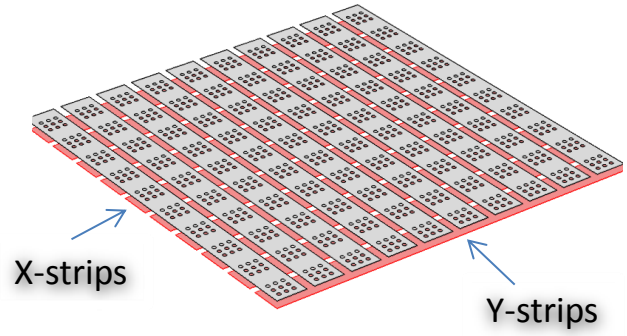
Building a Microbulk with x – y readout (Regular way):
Lengthy and very delicate process

- ✓Kapton foil (50 μm), double Cu-coated (5μm)
- ✓Construction of readout strips/pads (Photolithography)
- ✓Attachement of a single-side Cu-coated foil
- ✓Construction of readout lines
- ✓Etching of kapton
- ✓Vias construction
- ✓2nd Layer of Cu-coated kapton
- ✓Photochemical processing of mesh holes
- ✓Kapton etching
- ✓Cleaning



Aim of the project →

To develop microbulk Micromegas detectors with segmented mesh



1) **Real x-y structure**
2) **Mass minimization**
3) **Production Simplification**
4) **Large surface detectors**

Challenges:

1) Etching of y-strips

Keep y-strips fixed, Etching the kapton under the holes without completely removing the material in between the y-strips

2) No global trigger signal

use proper electronics → AGET (auto – trigger capability)

3) Provide bias on every y-strip

New Microbulk strip method: aims to simplify x – y formation

Serge FERRY-TE/MPE/EM
28/09/2012

1 Base material 50 µm polyimide foil copperclad

2 Photoresist liquid spinning, masking, exposure, development in clean room

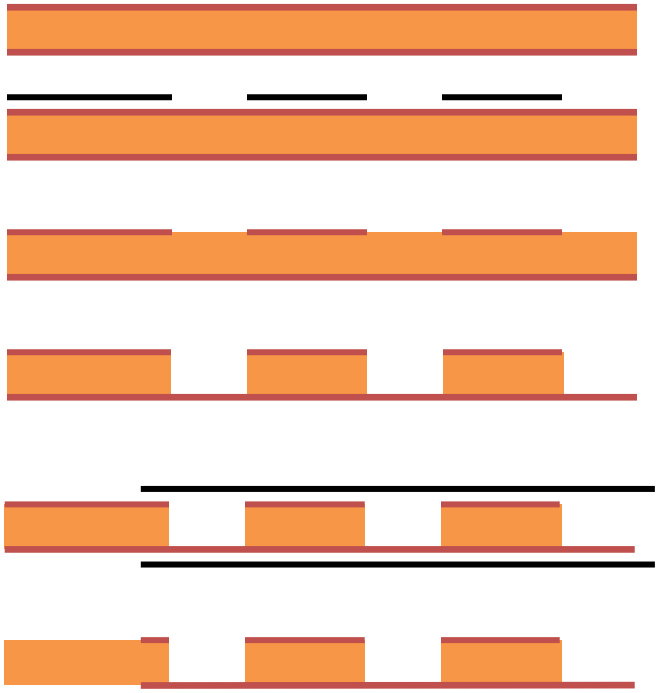
3 Chemical etching of copper grid of holes

4 Polyimide etching by sprayer

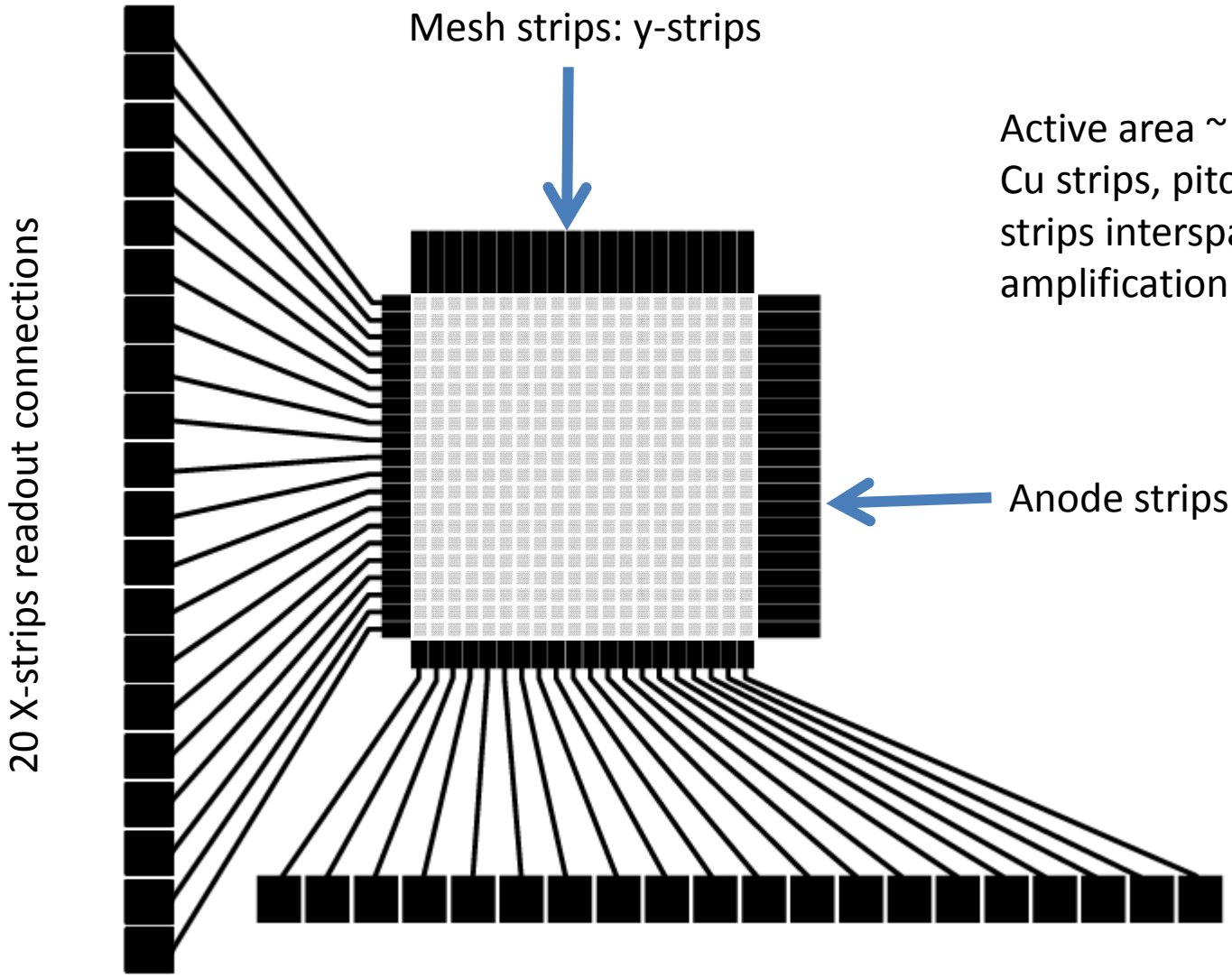
5 Photoresit lamination on top and bot for making strip,X and Y , masking,exposure, development

6 Chemical etching of copper top and bot + chemical etching of chromium

7 Cleaning + passivation, electrical test at 600v

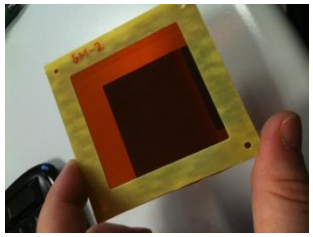


X-Y strips layout and readout connections



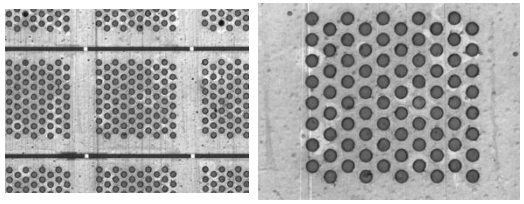
Production of "Real x-y" Micromegas

1st batch produced at CERN (Feb 2012)
Naked structure (no vias for connectors etc), few strips were operational, manual testing strip by strip, could not hold HV **Unsuccessful**

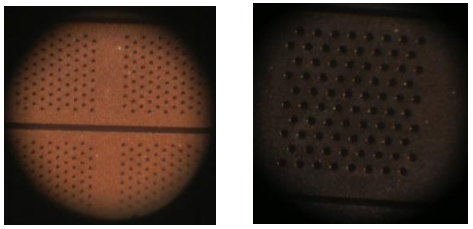


2nd batch was to be produced at CERN (Nov. 2012) :
New production technique – 4 Micromegas prototypes Hold HV, No spectrum from an ^{55}Fe source. **Partially successful**

3rd Batch of five Segmented Microbulk (July 2013)
Manufacturing: First the x-strips, then the mesh holes and finally the y-strips.
No holes on top of the x-strips gaps. Optimize the geometry with comsol
Successful (to be optimized)



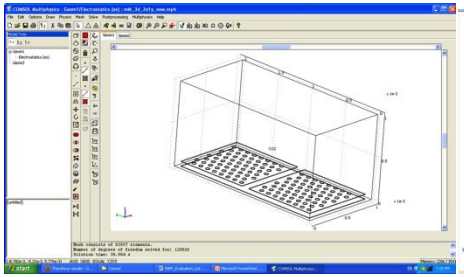
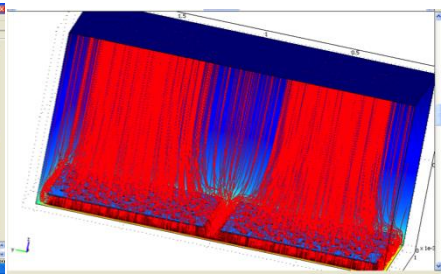
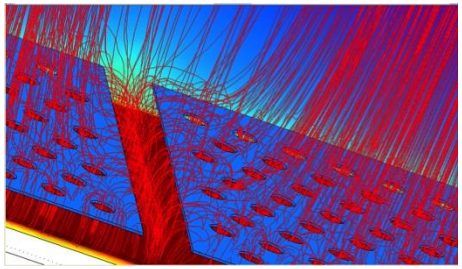
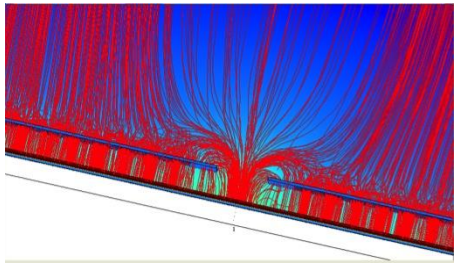
3 detectors: Mesh holes diameter = 60 μm, y-strips gap = 40 μm



2 detectors: Mesh holes diameter = 45 μm, y-strips gap = 40 μm

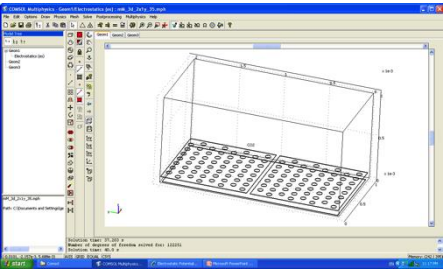
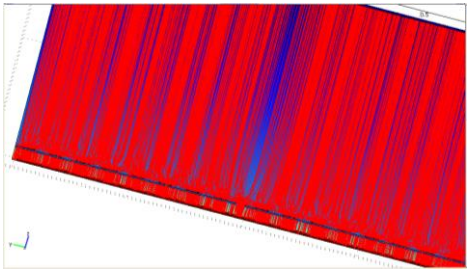
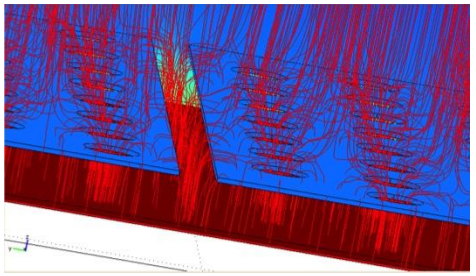
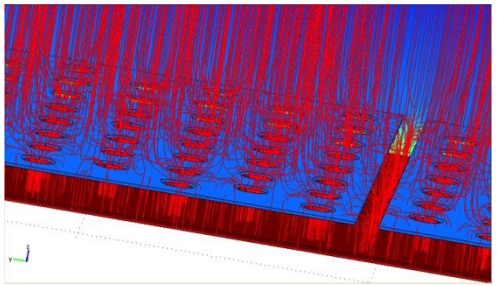
Layout Optimization using Comsol

Gap between y-strips: 100 um, Mesh holes: 50 um

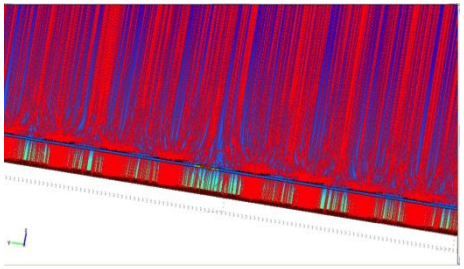
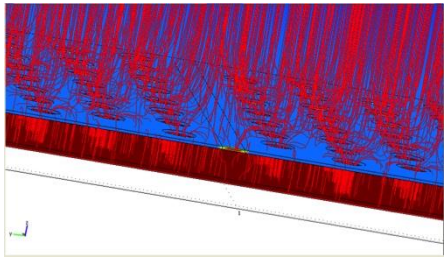





Electric Field

Gap between y-strips: 40 um, Mesh holes: 60 um

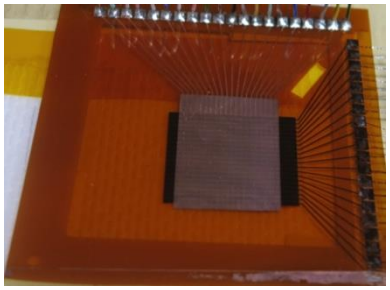
No Gap between y-strips: 40 um resistive, Mesh holes: 60 um

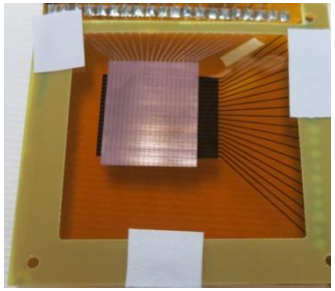
Detector Mounting for reading out the strips

“45 μm” mesh holes detectors
Raw detector

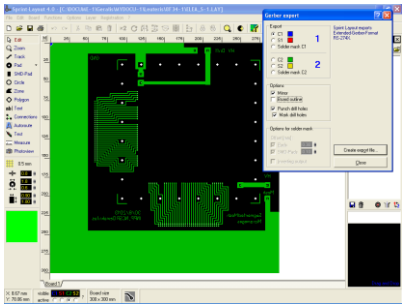
Y-strips side (Mesh)



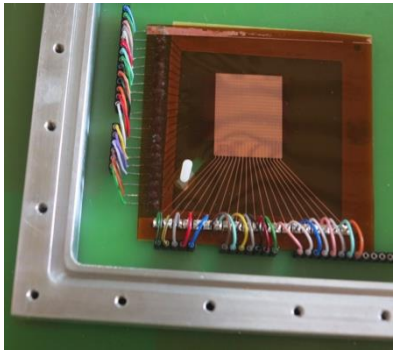
X-strips side (anode)



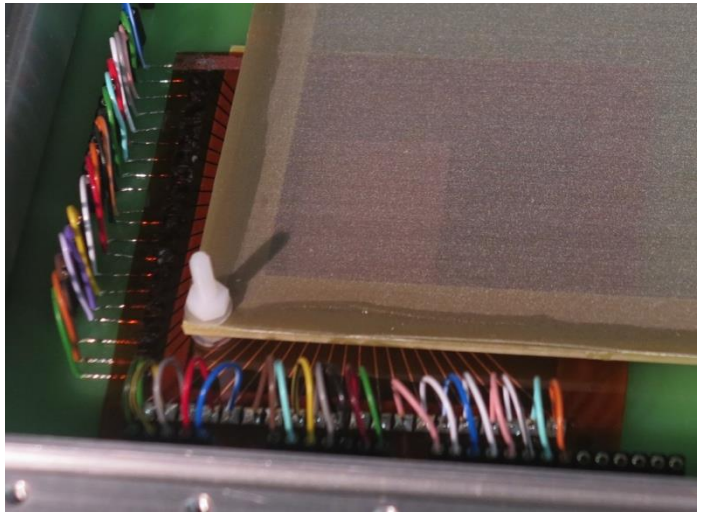
PCB design to host the Microbulk



Segmented Microbulk placed in the Cage with the strips connections

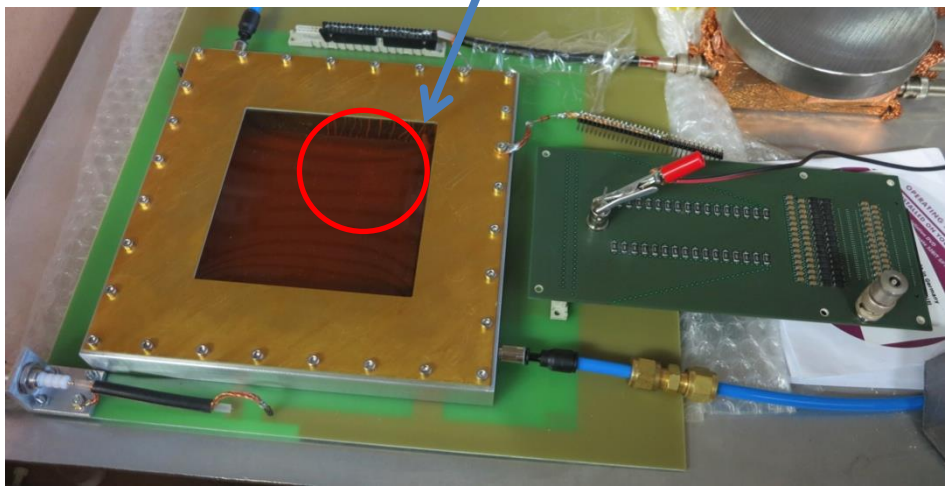


The drift electrode at 5mm

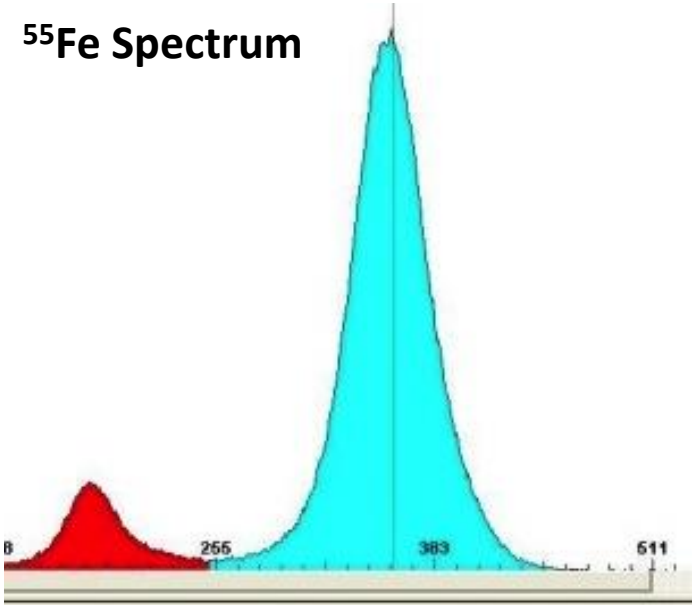


Segmented Microbulk Mounted HV Front-end Readout card connected

Microbulk



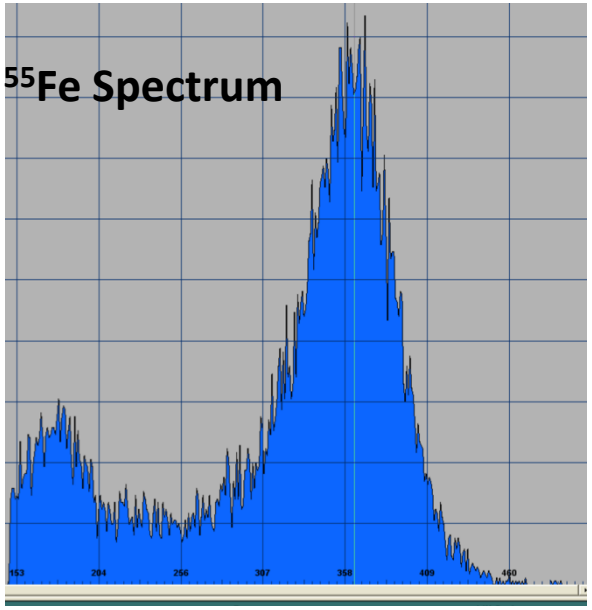
X and Y strips are both operational



REGULAR BIAS

V_{drift} = -360V
V_{mesh} = -330V
V_{anode} = 0 V

Common Y-mesh strips Readout
With preamplifier - Amplifier - MCA



REVERSE BIAS

V_{drift} = -30 V
V_{mesh} = 0V
V_{anode} = +330 V

Common X-mesh strips Readout
With preamplifier – Amplifier - MCA

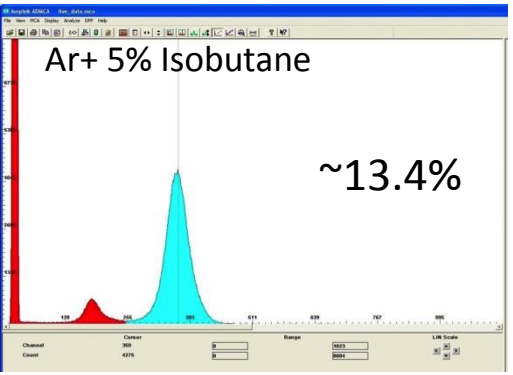
Segmented Microbulks (60μm)

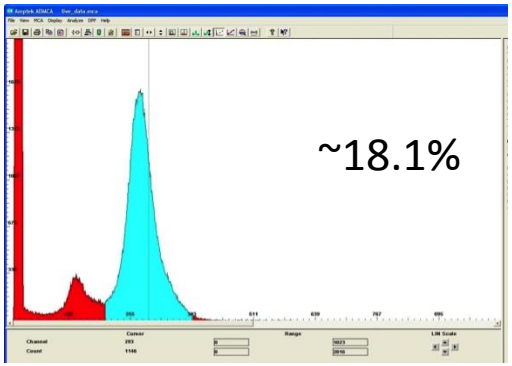
Good Energy resolution BUT …

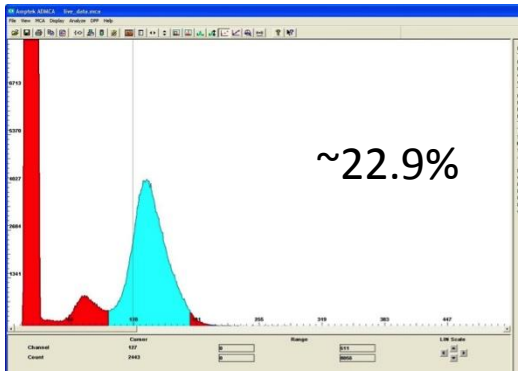
Problem: Different Energy resolution for the same type of microbulk

3 "60 μm" detectors

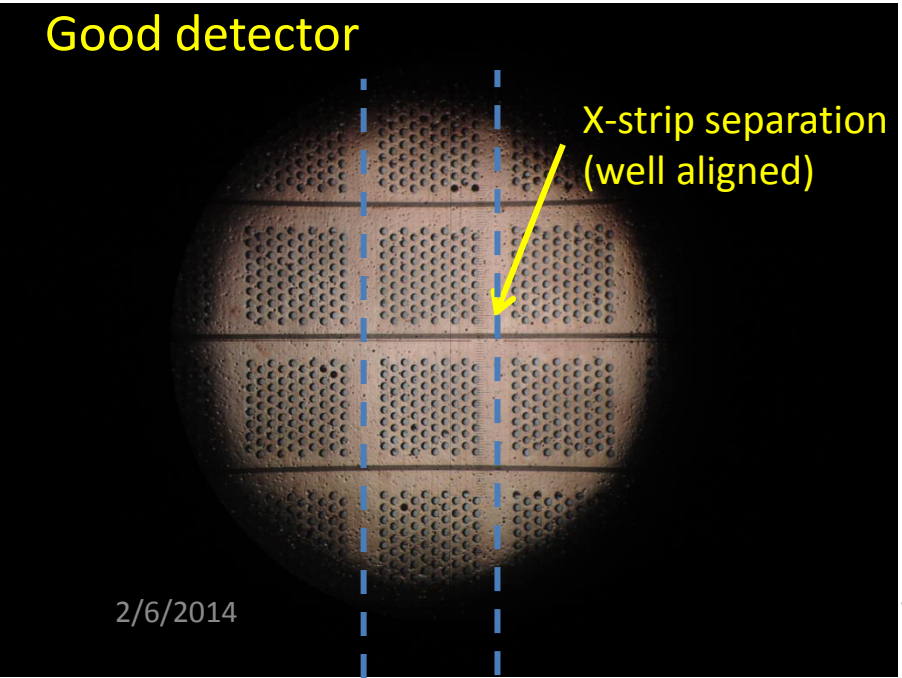
^{55}Fe X-ray source Spectra: ΔE/E FWHM @ 5.9 keV

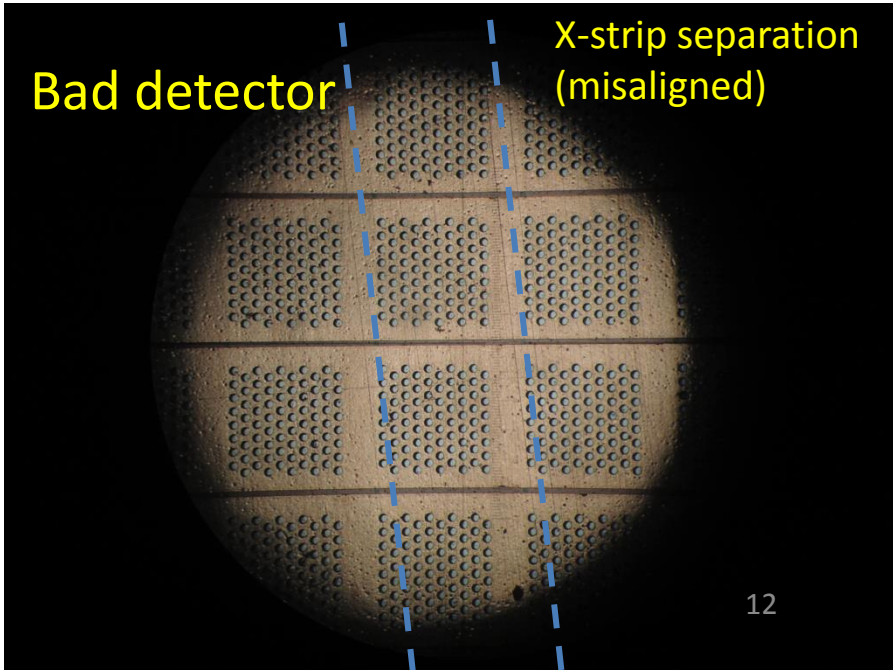




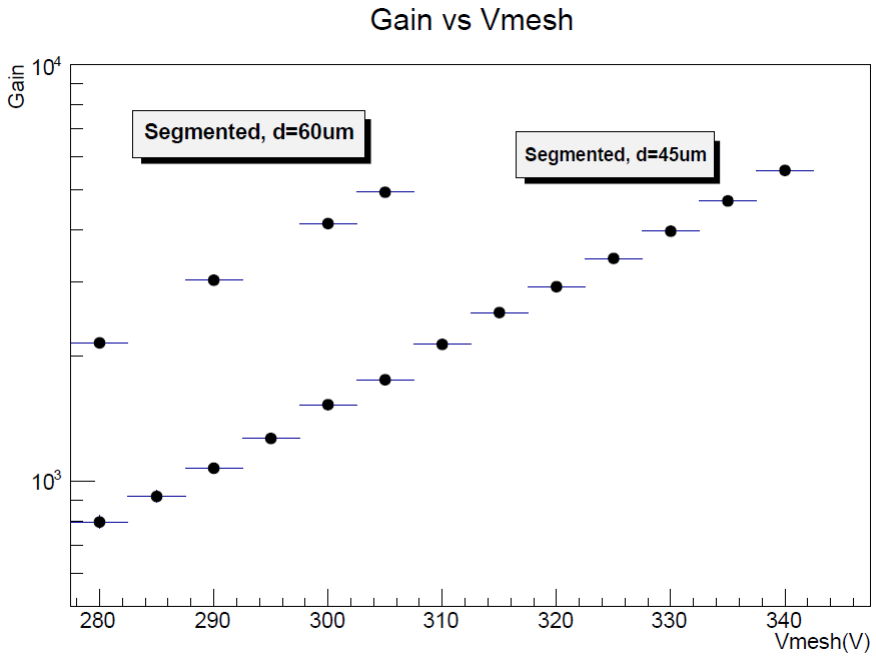


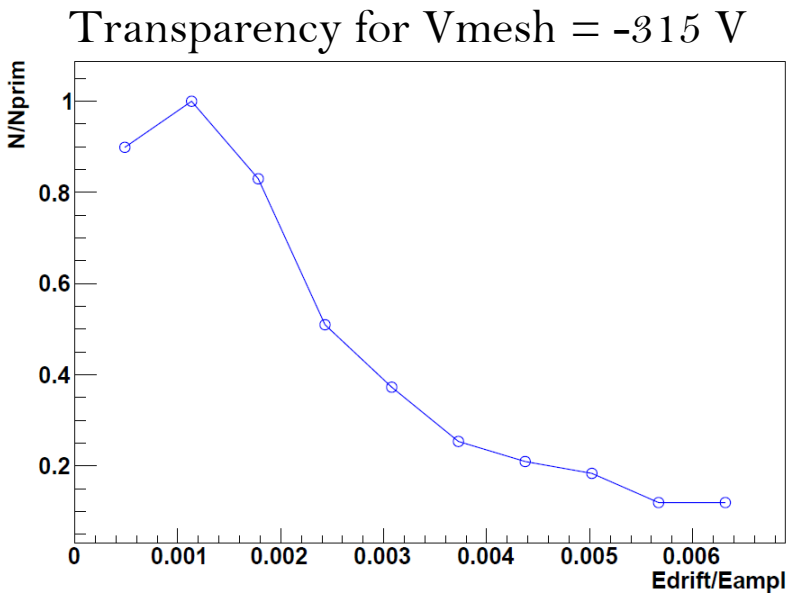
The problem was due to bad alignment of the x-strips during manufacturing





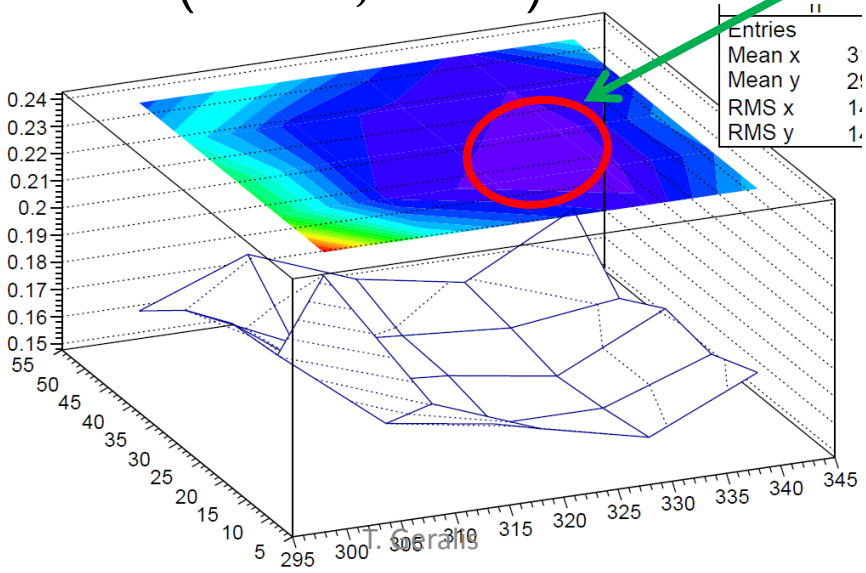
Gain and Transparency





Energy Resolution vs (Vmesh, Vdrift)

Vmesh (V)	Vdrift (V) = Vmesh +
300	+10
310	+20
320	+30
330	+40
340	+50



Best operating E field setting

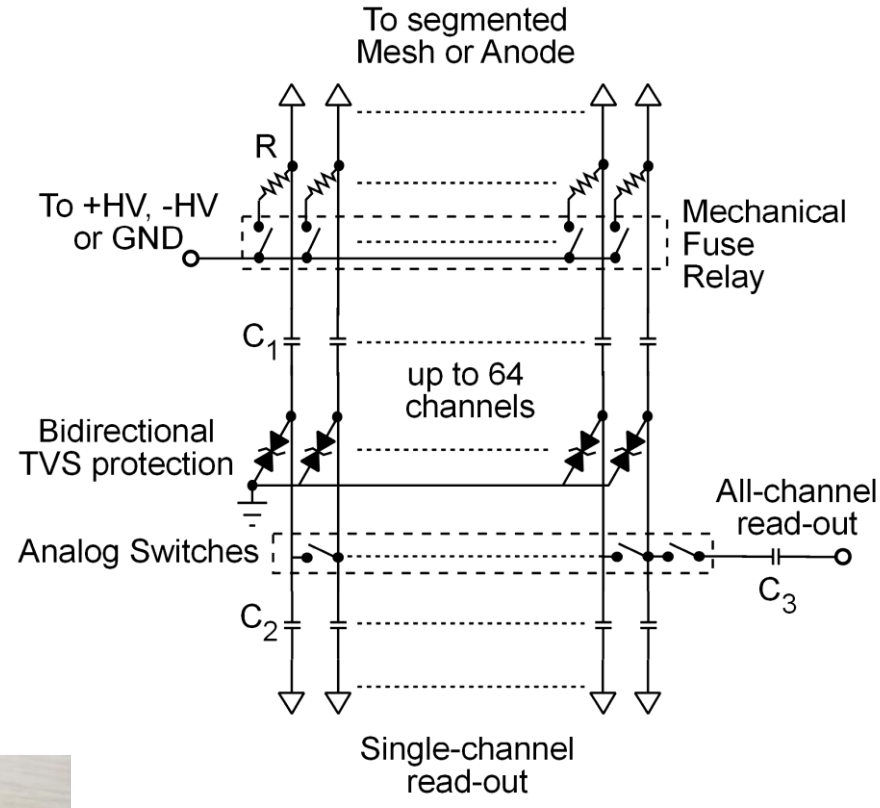
The mesh y-strips FE electronics

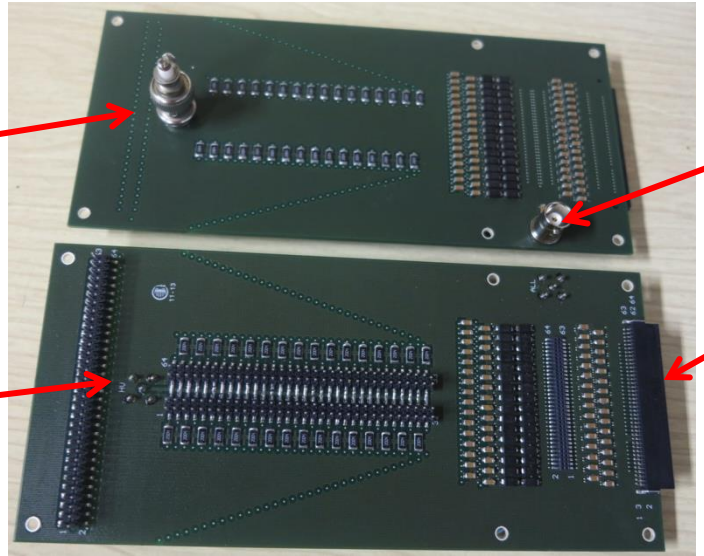
The mesh y-strips FE electronics

y-strips need to be supplied by the bias HV and be readout at the same time to provide the y information. A special Front End readout card was designed.

The circuit has the following characteristics:

1) **Readout up to 64 strips,**
2) **HV supply for every strip independently,**
3) **Selection of HV supplied strips individually,**
4) **Transient voltage suppression (TVS) protection and**
5) **Single-channel read-out and all-channel read-out.**





HV or GND
BNC connector

64-pin connector
to detector

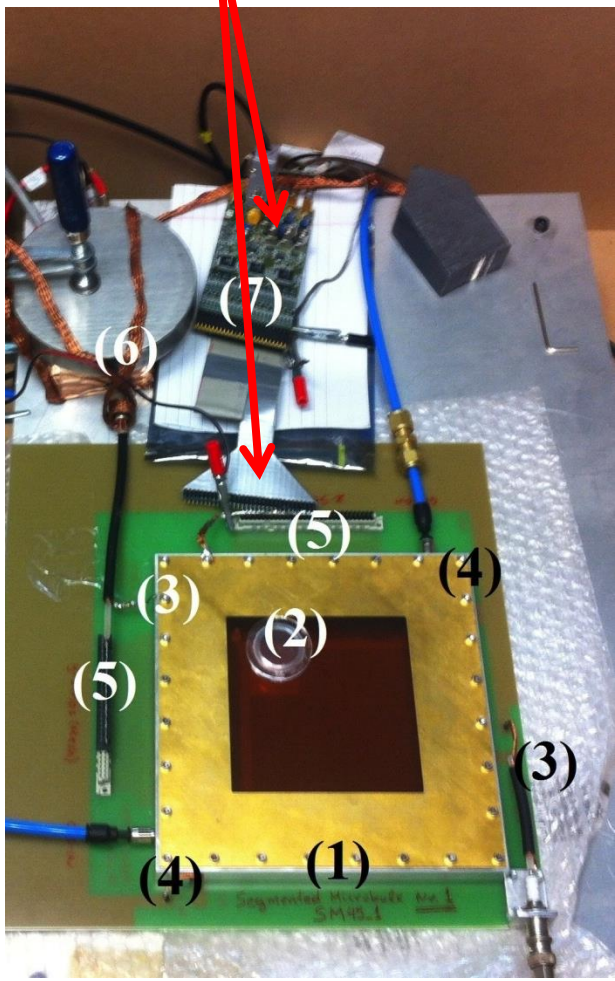
All strips readout
signal

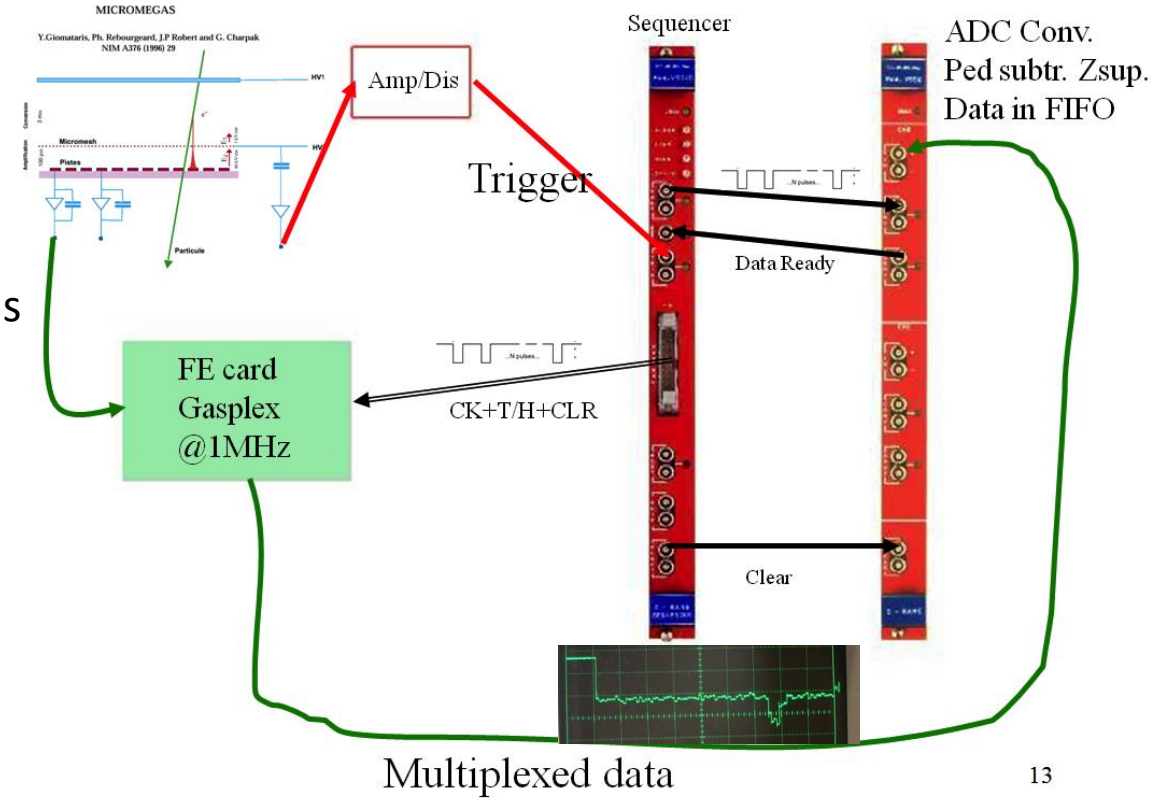
80-pin ERNI connector
To Readout (**AGET**)

S. Anvar et al. AGET, the Get Front-End ASIC, for the readout of the Time Projection Chambers used in Nuclear Physic Experiments. NSS/MIC/RTSD IEEE, 2011.

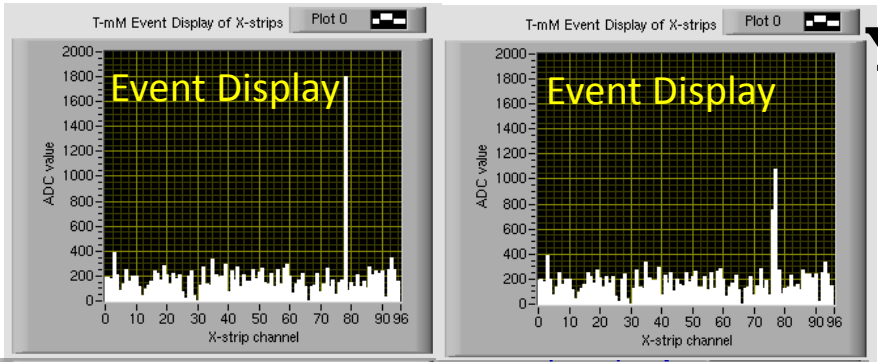
Reading out the X-strips or the Y-strips with the Gassiplex DAQ

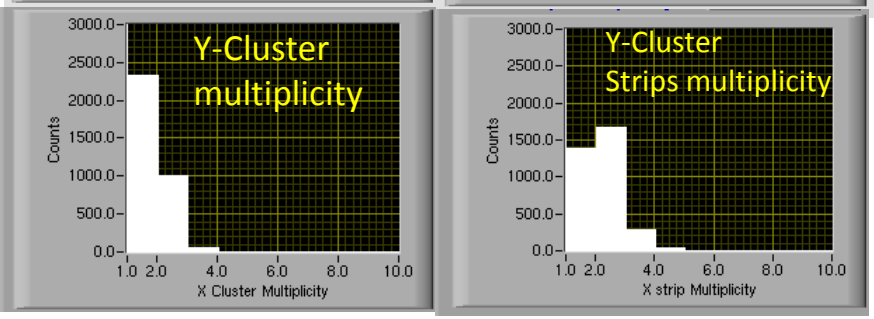
Gassiplex and Adaptor
To the segmented microbulk

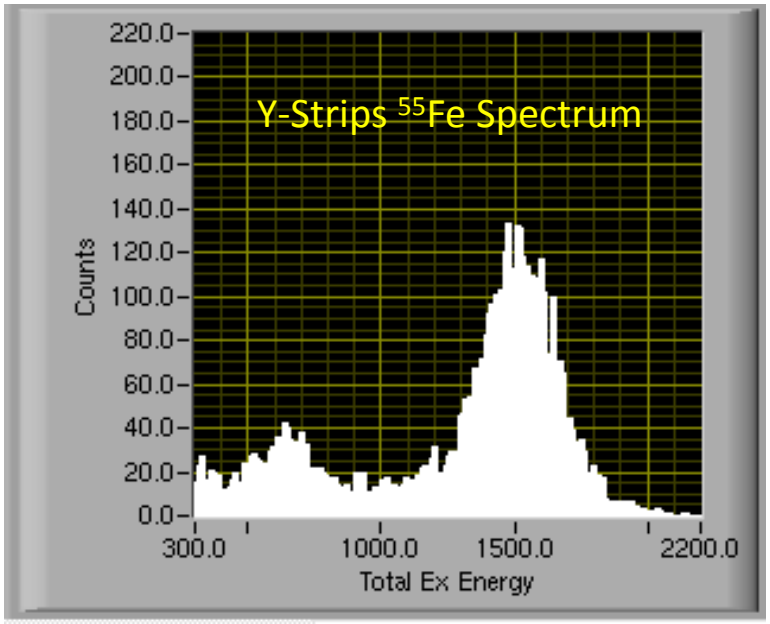




Reading out the X-strips or the Y-strips with the Gassiplex DAQ







READOUT X-Strips (Anode strips)

V_{drift} = -360V
V_{mesh} = -330V (REGULAR BIAS)
V_{anode} = 0 V

Common (Shorted) Y-mesh strips signal is used as trigger

READOUT Y-Strips (Mesh strips)

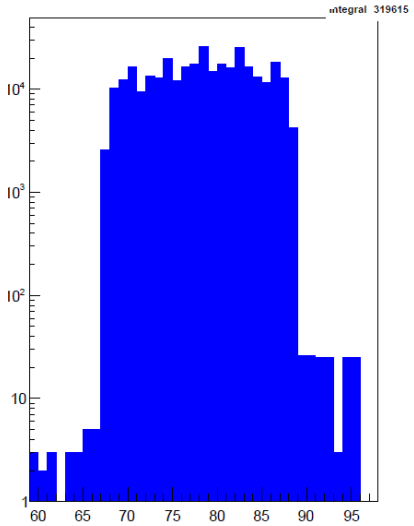
V_{drift} = -30V
V_{mesh} = 0V (REVERSED BIAS)
V_{anode} = +330 V

Common (Shorted) X-anode strips signal is used as trigger

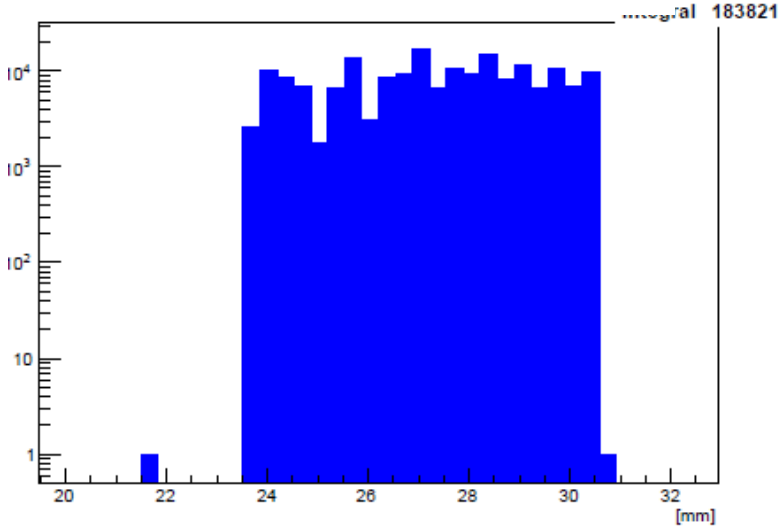
Y-mesh strips readout
Event Display and Monitor plots for Multiplicities and the ^{55}Fe spectrum

Data Analysis: Hit maps, Strip multiplicity, Cluster multiplicity, Energy spectrum

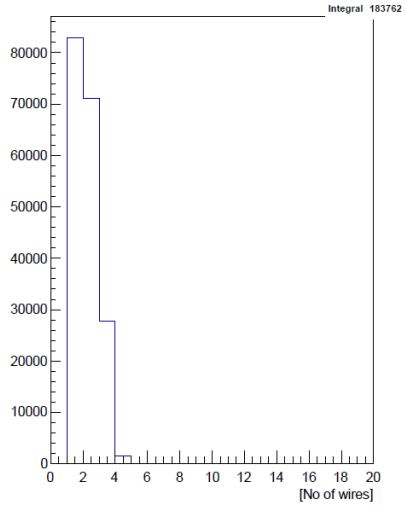
Hit - map



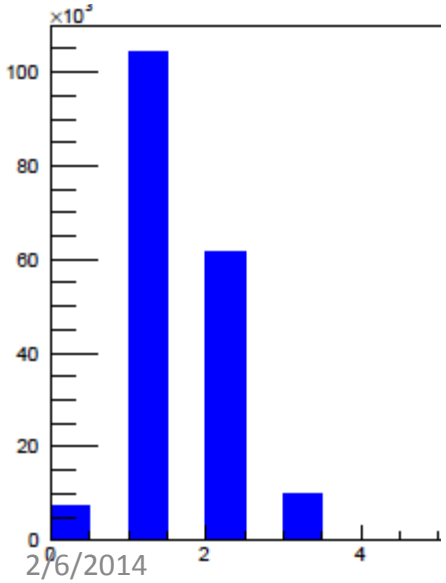
X-Cluster distribution



Event Cluster Multiplicity



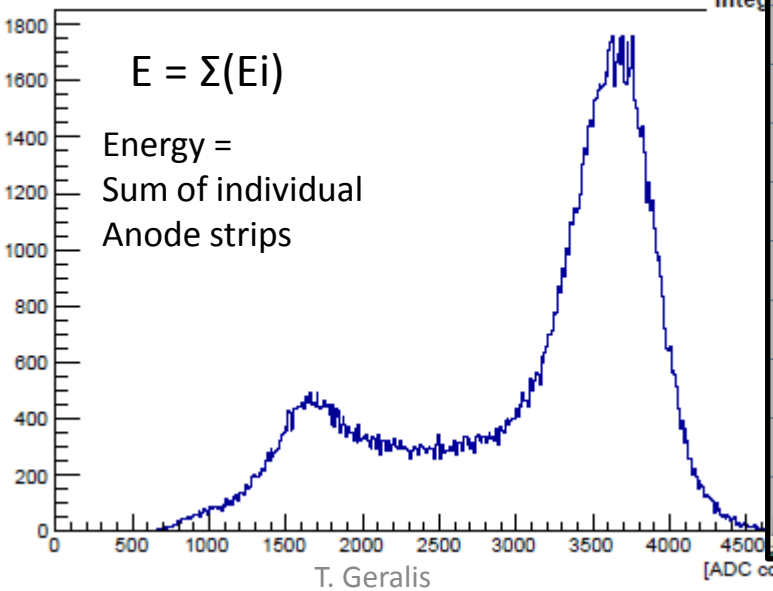
Cluster-Strips multiplicity

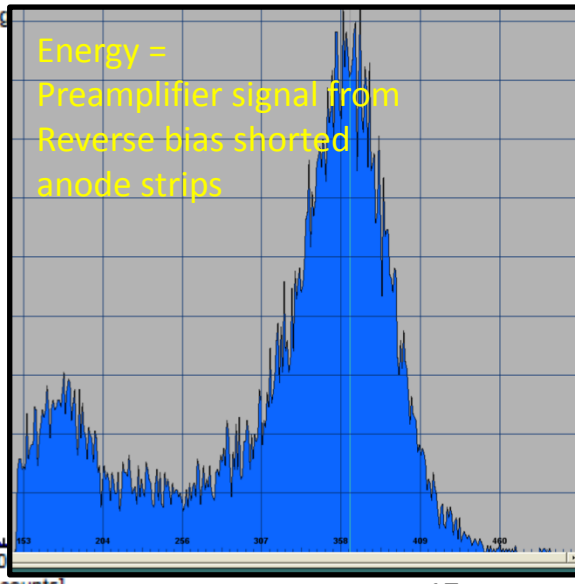


^{55}Fe Energy spectrum

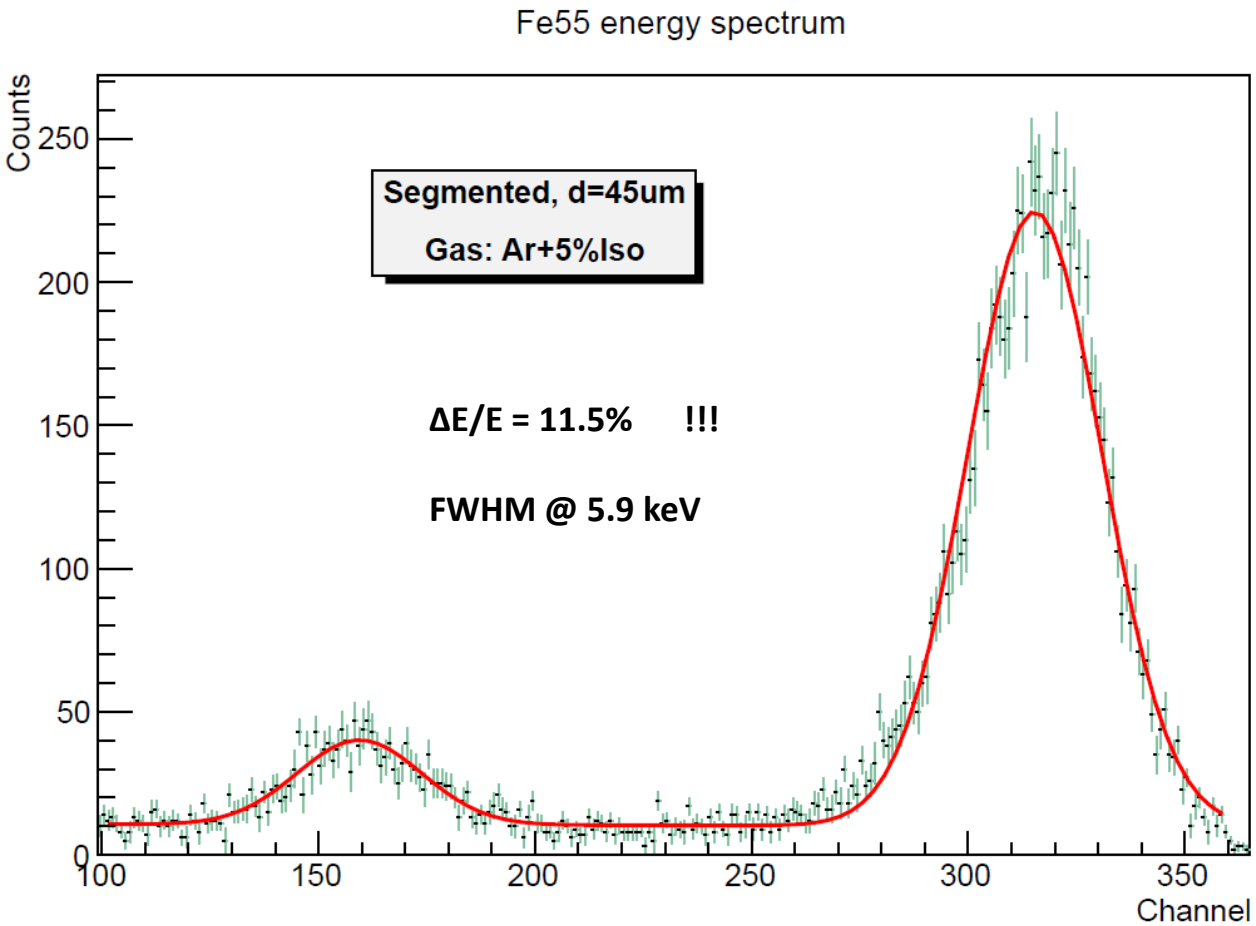
$E = \Sigma(Ei)$

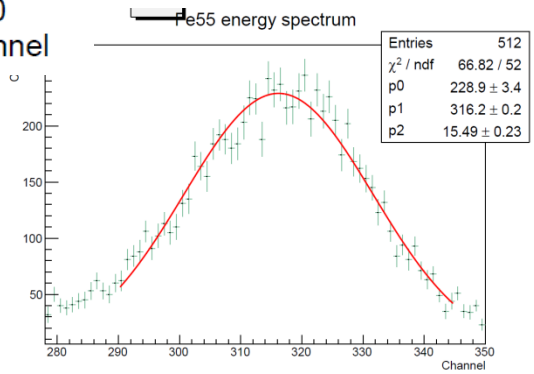
Energy =
Sum of individual
Anode strips





Our best result:
Energy resolution close to the statistical limit of 11%





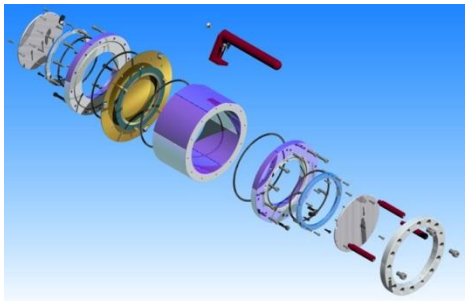
Emerging applications

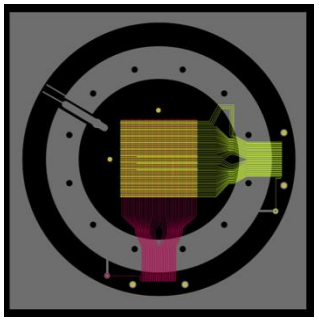
Rare searches (axion, dark matter)

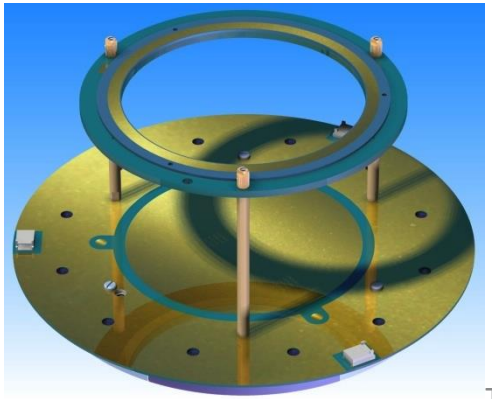
Microbulk background: ~ 10^{-6} cnts/keV/cm^2/s

The segmented microbulk can further push the background → ~ 10^{-7} cnts/keV/cm^2/s

Neutron Beam profiler (nTOF)







Very adequate due to very low material badget
5 μm + 5 μm of Cu only

IRFU Saclay (Thomas Papaevangelou) who is member of our project, has started a design for nTOF for neutron profiler using segmented

CONCLUSIONS

•First successful construction and operations of a segmented mesh microbulk micromegas. Excellent properties: good charge collection and Energy resolution

•On going work: Optimize the Detector design and obtain full readout chain

•Further work is needed to standardize, consolidate and simplify the production

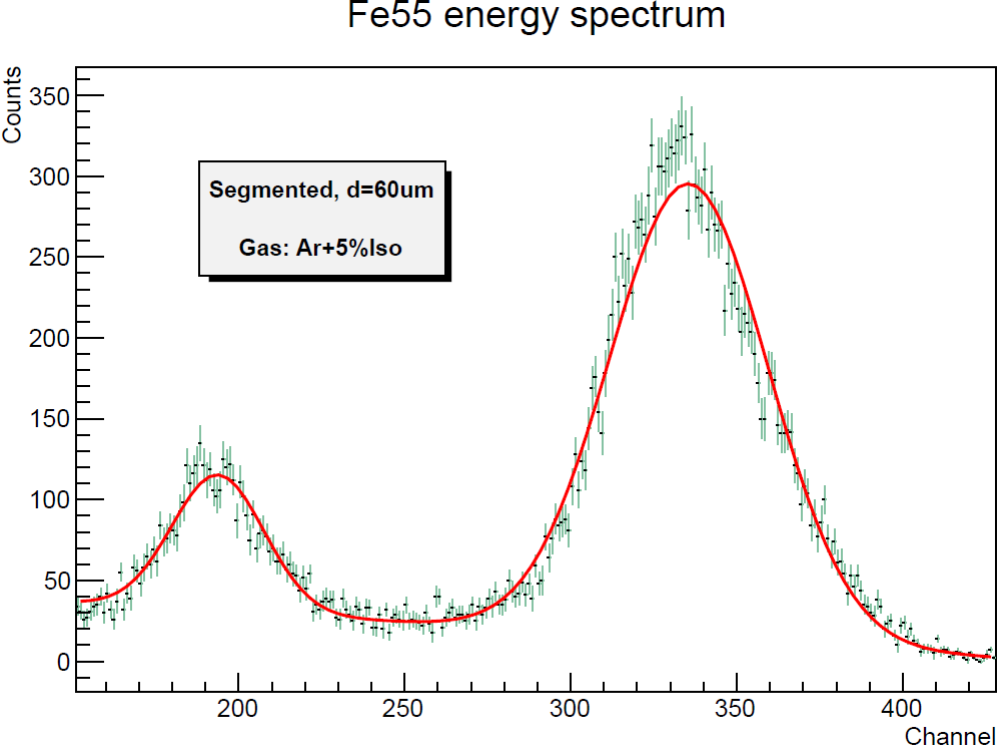
•Excellent prospects for a extra low background detector for rare searches

•There are already ideas and projects for applications: 1) Neutron beam profilers and 2) In rare event searches (Axions, Dark matter)

THANKS FOR YOUR ATTENTION

BACKUP SLIDES

Gain and Energy resolution



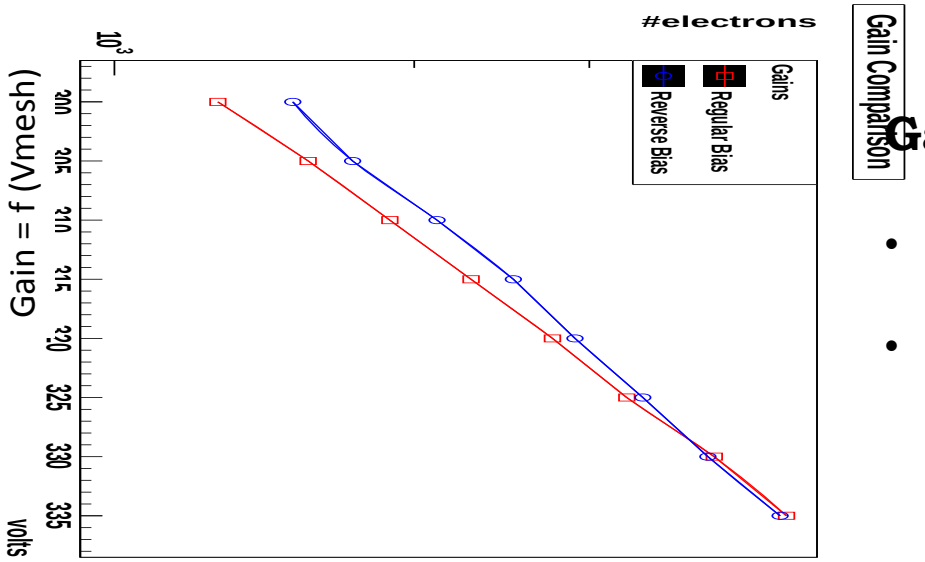
Segmented Microbulk (60µm)

^{55}Fe Spectrum

Energy Resolution @ 5.9 keV = ~16.8% FWHM

Gain vs Vmesh

Vmesh = 305 V at max for this detector



Gain curve for a "45µm" detector

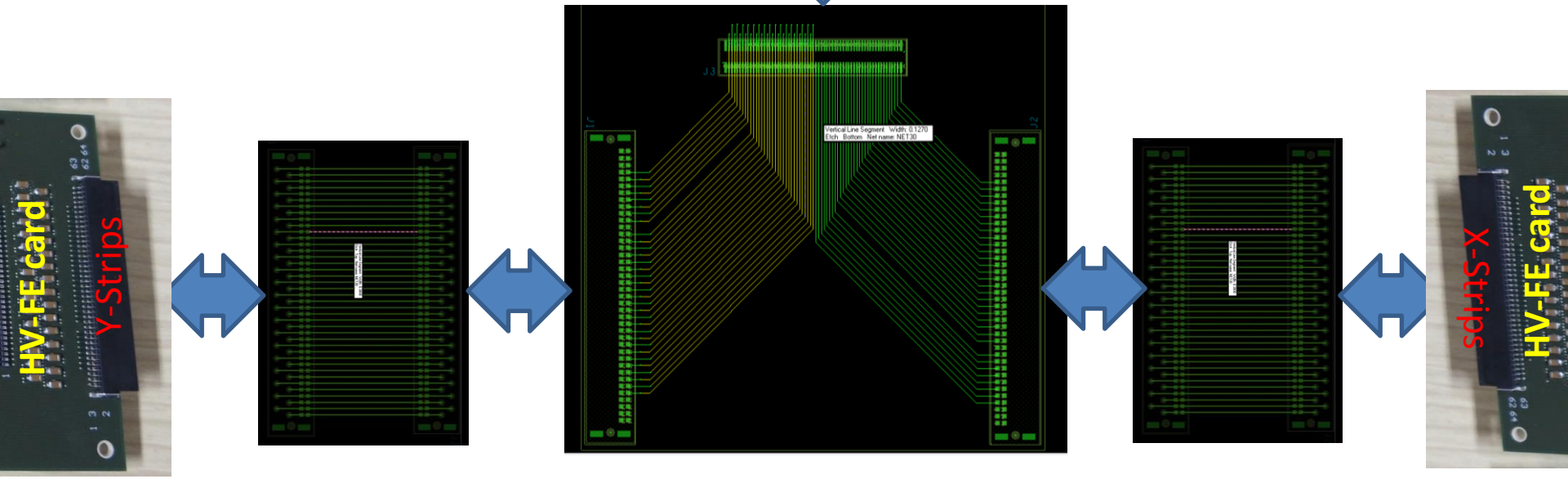
- For regular (Y-strips common readout) HV Bias and for
- Reversed (X-strips common readout) HV bias

Interface from the HV-FE cards To the VMM1 readout chain

Readout 64 channels
32 x-strips + 32 y-strips

ATLAS ASIC for MAMMA
Auto trigger, amplitude and timing information, neighbor channel logic.

Panasonic connector



Alternative Readout based on the VMM1 chip is being worked to be used with the segmented microbulk shortly

Current activities and Plans

1) HV Front End card testing and validation

2) Reduced strips pitch to 700 μm (under construction)

3) Build larger area detectors

4) Further optimize the design (geometry: reduced or resistive gap)

5) Use AGET or VMM1 readout electronics for full event readout and possibility to use it in TPC mode