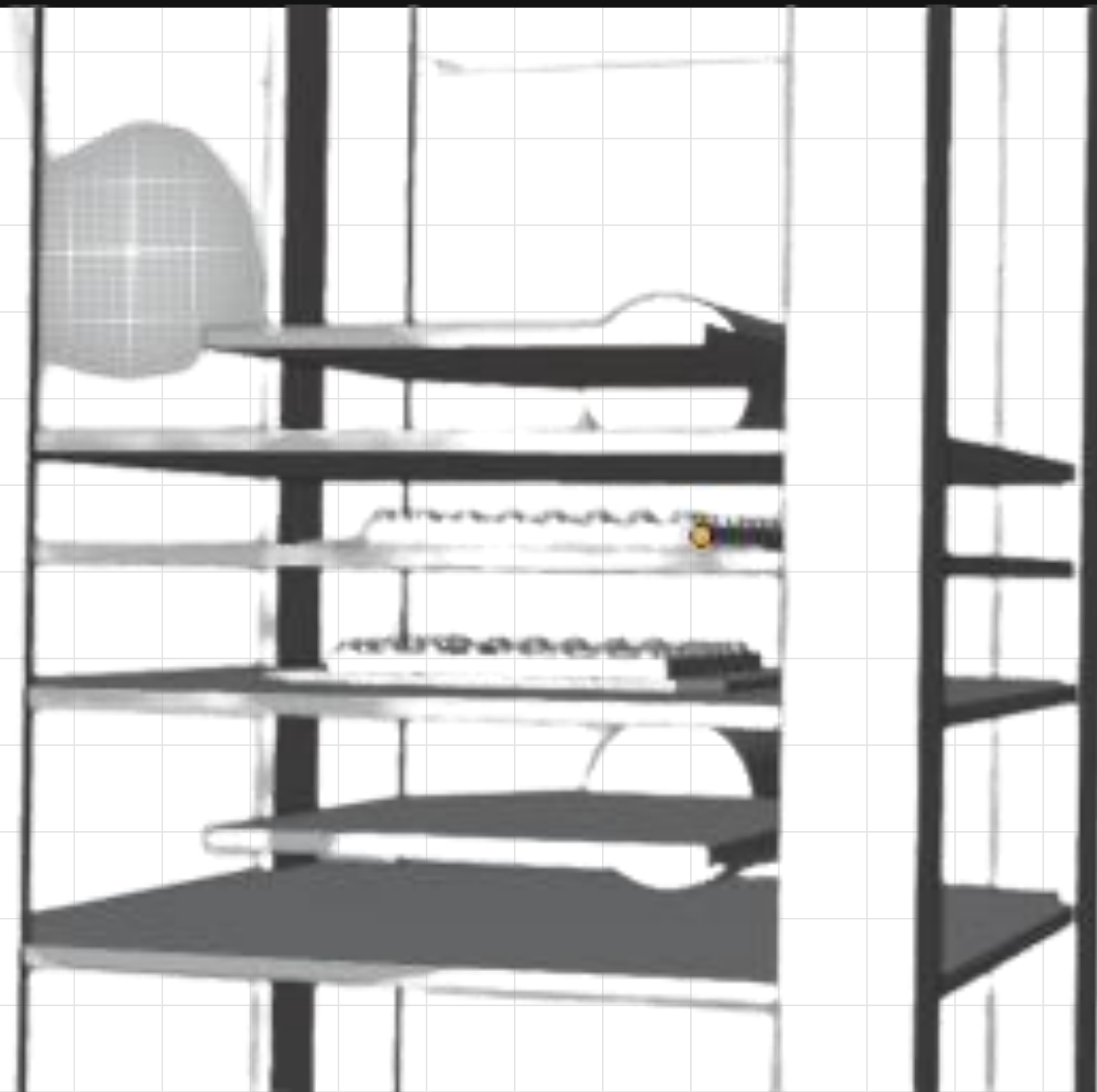


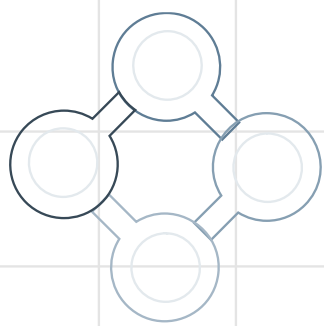
# Hodoscopio GEM con lectura SRS

Autor: Brayan Garcia

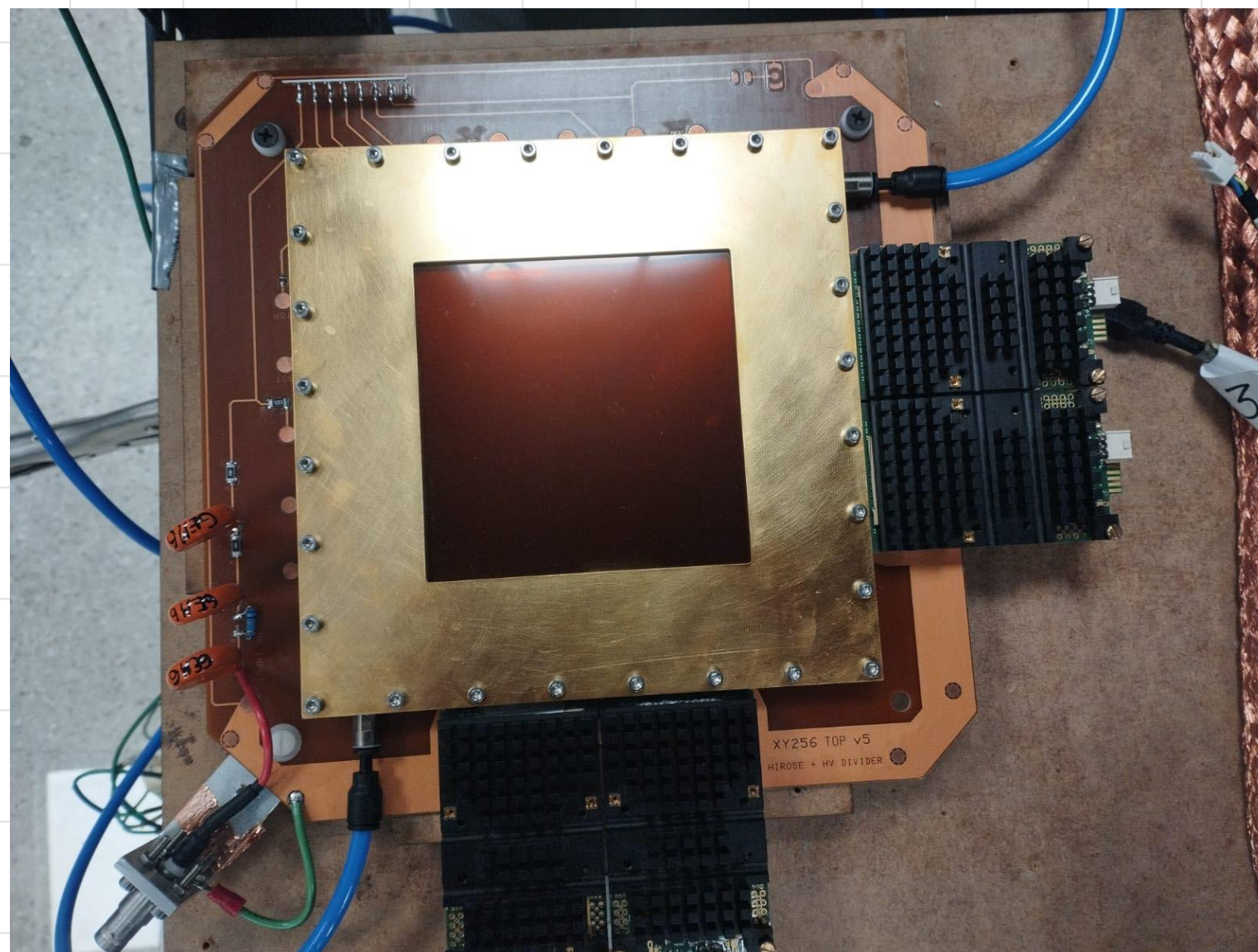
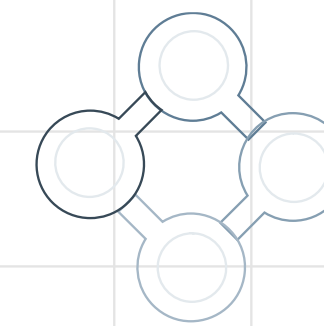
Coautor: Carlos Avila



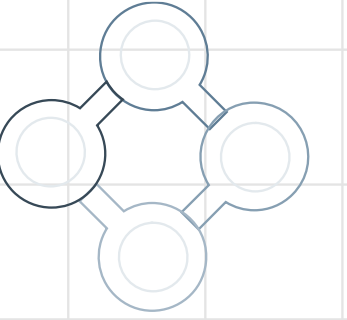
Universidad de los Andes | Grupo de Investigación  
Altas Energías



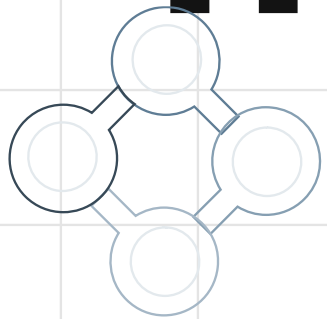
# Detector GEM



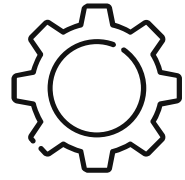
- *Utiliza gas noble*
- *Resolución Energética de 18% FWM a 5.9 keV*
- *Resolución Espacial de 60  $\mu\text{m rms}$*
- *Ganancia proporcional  $10^5$*



# ¿Podemos hacer tracking de muones?

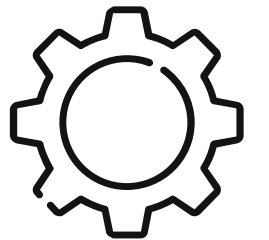
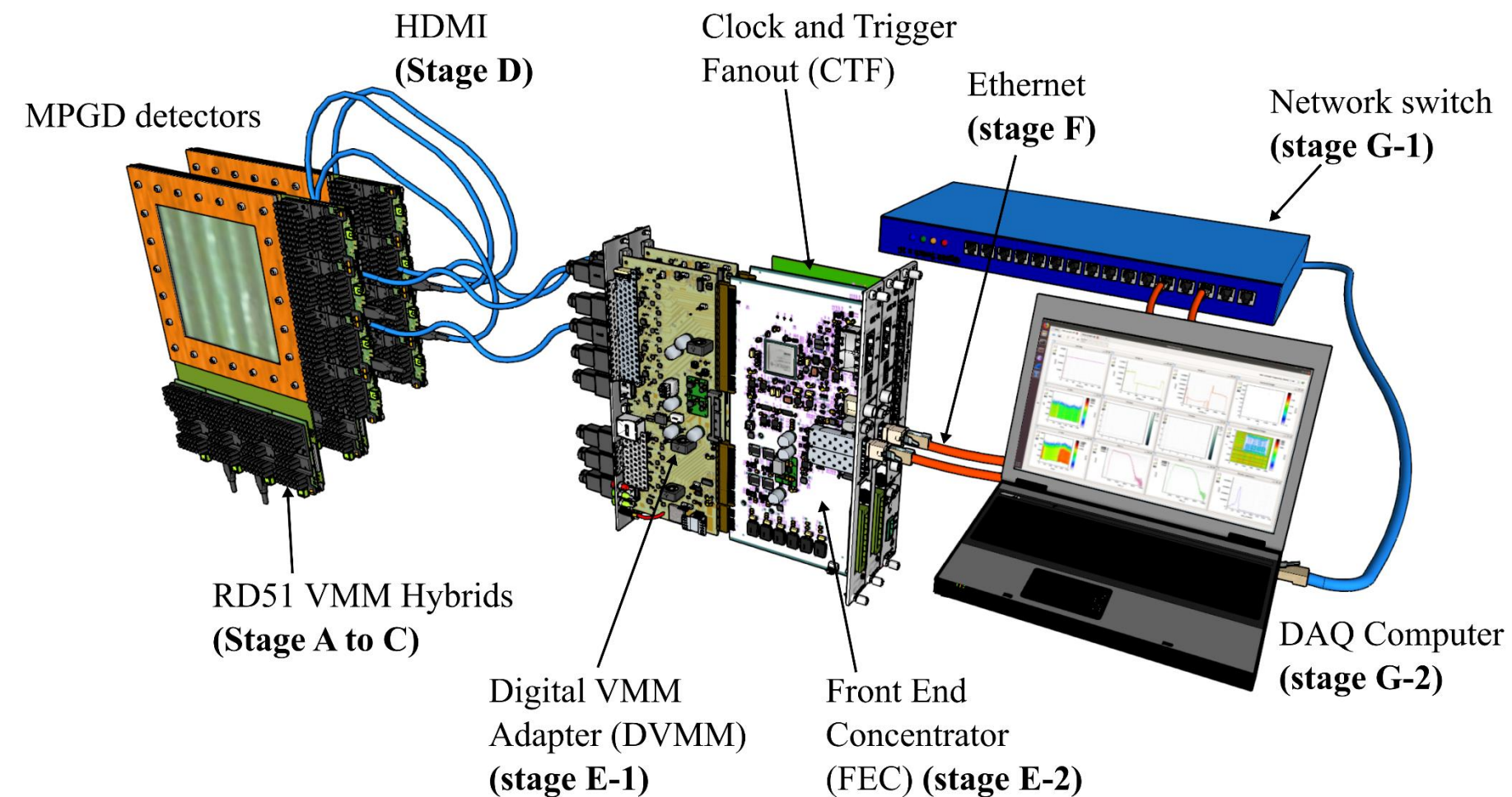


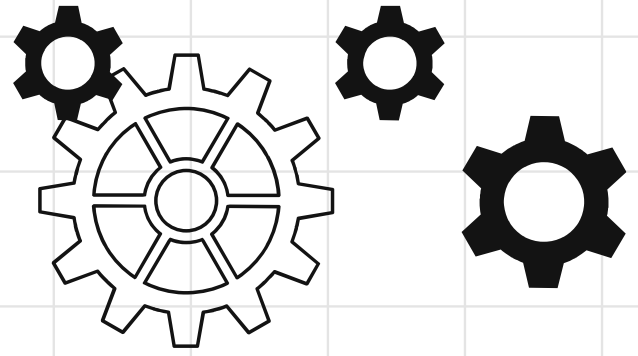
# Sistema de Adquisición SRS



## Sistema Escalable de Lectura (SRS)

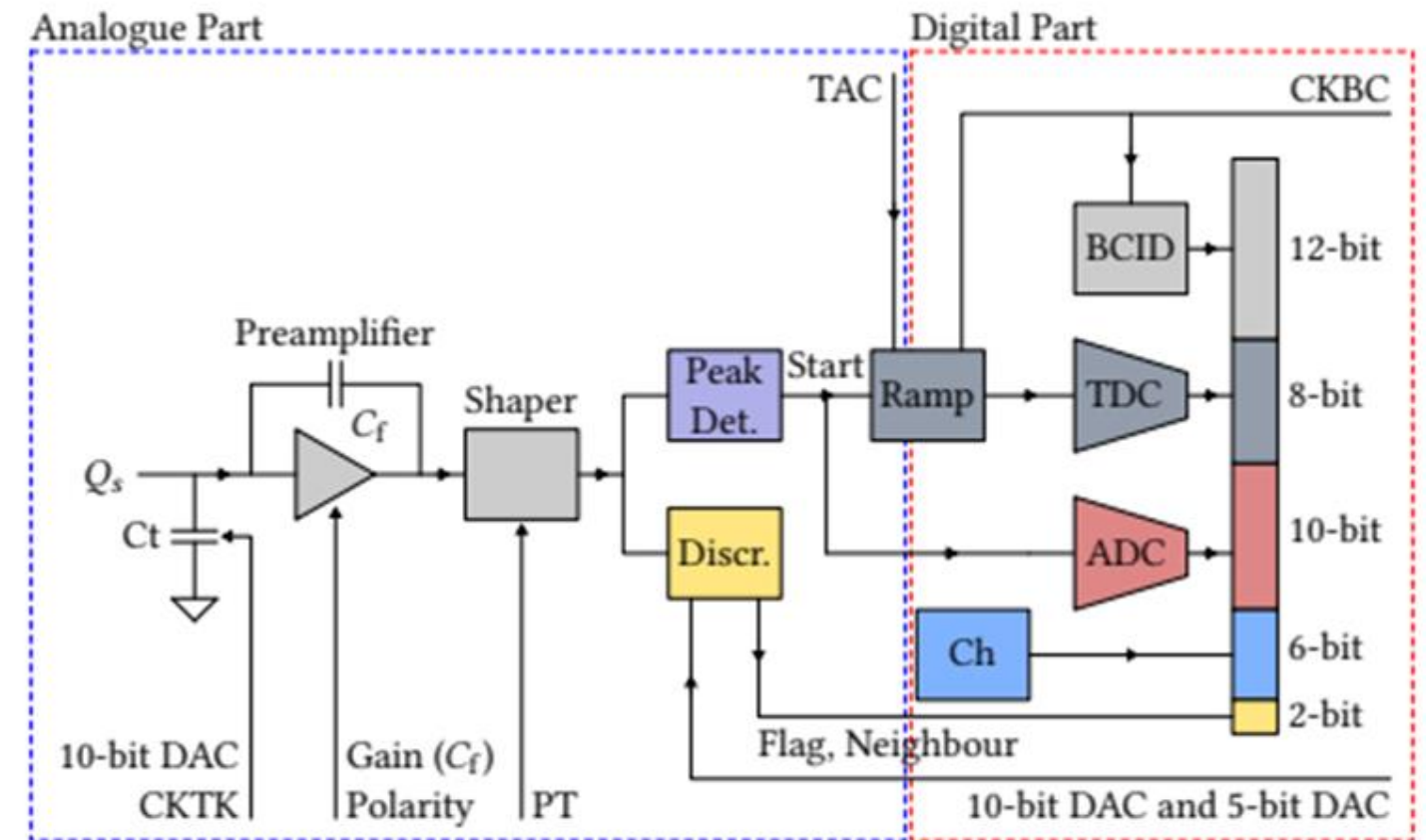
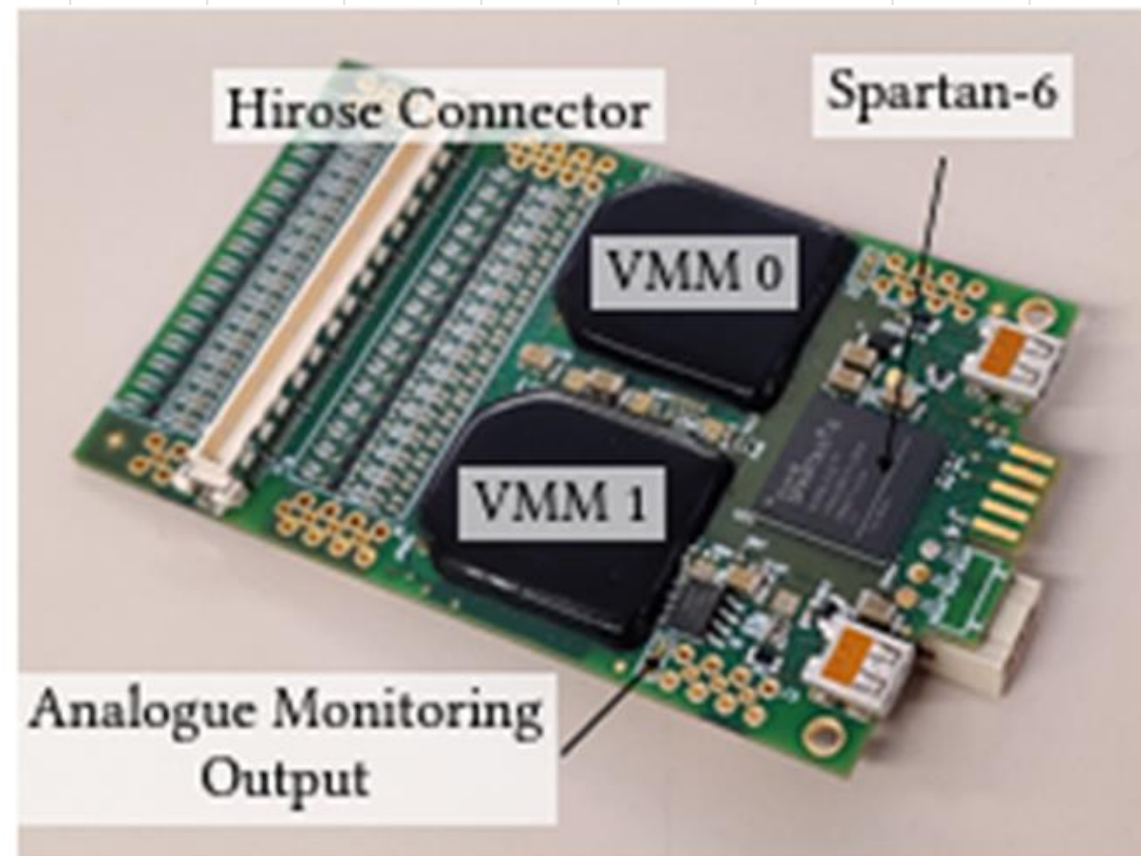
### Desarrollado por el laboratorio RD51





# Chip Vmm

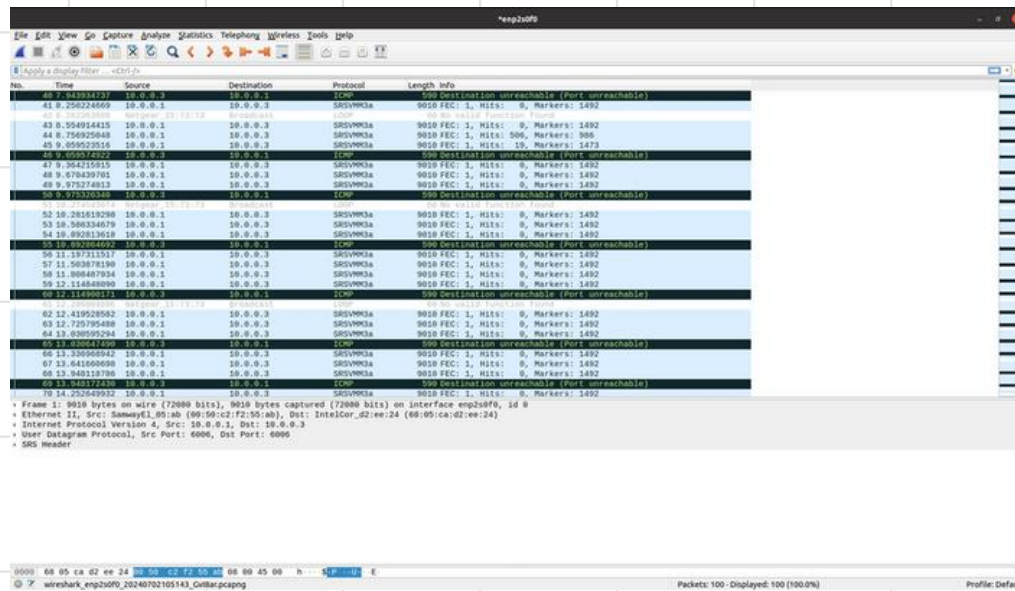
Chip de 64 Canales  
Desarrollado en el Laboratorio  
Brookhaven



Tomado de:  
X-ray imaging with gaseous detectors using the VMM3a and the SRS

# Software de Adquisición

## Wireshark



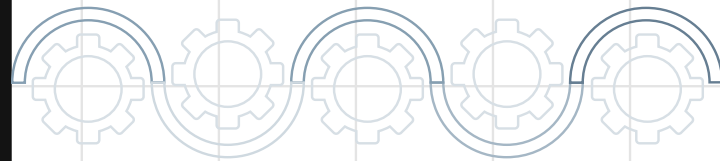
## Tcpdump

```
labhep@PCGEM:~/data/2024-01/Brayan MSc/prueba$ sudo timeout 30 tcpdump -i enp2s0
f0 -w Prueba30segundos.pcapng udp port 6006
[sudo] password for labhep:
tcpdump: listening on enp2s0f0, link-type EN10MB (Ethernet), capture size 262144
bytes
97 packets captured
98 packets received by filter
0 packets dropped by kernel
labhep@PCGEM:~/data/2024-01/Brayan MSc/prueba$
```

## Vmm-sdat

```
try:
args = ['/home/labhep/sw/vmm-sdat/bin/convertFile',
'-f', current_directory+'/'+PMT1680V_pt25_ambosCanales.pcapng',
'-vmm',
'\
[1,0,1,0],[1,0,1,1],[1,0,1,2],[1,0,1,3],[1,1,1,4],[1,1,1,5],[1,1,1,6],[1,1,1,7],[2,0,1,8],[2,0,1,9],\
]',
'-axis',
'\
[[1,0],0],[1,1],0,\
]',
#'-sc', '[0.391,0.391,1],[0.391,0.391,1]]',
#'-tl', '[-51.2, -51.2, 100],[-51.2, -51.2, 100]]',
#'-ro', '[0,0,0],[0,0,0]]',
#'-tr', '[S,T,R2],[S,T,R2]]',

'-bc', '40',
'-tac', '60',
'-th', '0',
'-cs', '1',
'-ccs', '2',
'-dt', '200',
'-mst', '2',
'-spc', '500',
'-dp', '200',
'-coin', 'center-of-mass',
'-cr1', '0.5',
'-cru', '2',
'-save', '[[1,2],[1,2],[1,2]]',
'-stats', '1',
```



# Software de Adquisición

VMM Slow Control Calibration Logging Testing

Open Communication  
N/A  
Send

Reset Warnings

FEC  
 1  
 2  
 3  
 4  
 5  
 6  
 7  
 8

ACQ for all FECs  
 ACQ On  
 ACQ Off

Config file  
 Load  
 Save

FEC 1  
 IP address FEC  
 10.0.0.2 FEC IP  
 10.0.0.3 DAQ IP

Hybrids  
 1  2  3  4  
 5  6  7  8

Acquisition/Test pulse  
 47 reset latency  
 4091 data latency maximum  
 4 data latency error  
 debug data format  
 64 latency TP  
 100 offset first TF  
 1 number of TPs  
 1000 offset next TPs  
 off Trigger In  
 off Trigger Our  
 0 Trigger Our Time

ACQ  
 On Off

FEC Status  
 Warm Init FEC  
 Link Status  
 System Parameters  
 Clear Info

Hybrid 1 Hybrid 2

VMM  
 1  2

Position  
 Axis Y  
 Position 1

I2C  
 Hybrid ID  
 Read

S6  
 CKBC 40MHz  
 CKBC skew 0.00 ns  
 CKDT 180 MHz

Test Pulse  
 Skew 0 ns  
 Width 128x2  
 Polarity Posith  
 Apply to all hybrids

VMM 1 VMM 2

General Settings Advanced Settings

Input charge polarity negative  
 Analog (Channel) Monitor Temperature sensor  
 Gain (sg) 3.0 mV/IC  
 TAC Slop Adj (stc) 60 ns  
 Peak time (st) 200 ns  
 ReadADC ADC res.  
 SRAT Mode Timing At Peak  
 Neighbor Trigger (sng) Disable At Peak  
 Analog tristates Sub Hysterisis

ADC  
 ADCs on/off 8-bit Conv. Mode  
 10b ADC (Ampl) 200 ns  
 6b ADC (Direct out) 25 ns  
 8b ADC (Time) 100 ns

Dual Clock  
 Dual Clock ART Dual Clock Data Dual Clock 6-bit

Threshold DAC 300 265 mV  
 Test Pulse DAC 300 269 mV DAC 393 mV pulse height

All VMMs: Settings and reset  
 Set global settings Set channel settings

Channel Settings  
 SD SZ010b SZ08b SZ06b  
 SC SL ST STH SM 0 mV SMX 0 mV 0 ns 0 mV

0					0 mV		0 mV	0 ns	0 mV
1					0 mV		0 mV	0 ns	0 mV
2					0 mV		0 mV	0 ns	0 mV
3					0 mV		0 mV	0 ns	0 mV
4					0 mV		0 mV	0 ns	0 mV
5					0 mV		0 mV	0 ns	0 mV
6					0 mV		0 mV	0 ns	0 mV
7					0 mV		0 mV	0 ns	0 mV
8					0 mV		0 mV	0 ns	0 mV
9					0 mV		0 mV	0 ns	0 mV
10					0 mV		0 mV	0 ns	0 mV
11					0 mV		0 mV	0 ns	0 mV
12					0 mV		0 mV	0 ns	0 mV
13					0 mV		0 mV	0 ns	0 mV
14					0 mV		0 mV	0 ns	0 mV
15					0 mV		0 mV	0 ns	0 mV
16					0 mV		0 mV	0 ns	0 mV
17					0 mV		0 mV	0 ns	0 mV
18					0 mV		0 mV	0 ns	0 mV
19					0 mV		0 mV	0 ns	0 mV
20					0 mV		0 mV	0 ns	0 mV
21					0 mV		0 mV	0 ns	0 mV
22					0 mV		0 mV	0 ns	0 mV
23					0 mV		0 mV	0 ns	0 mV
24					0 mV		0 mV	0 ns	0 mV
25					0 mV		0 mV	0 ns	0 mV
26					0 mV		0 mV	0 ns	0 mV
27					0 mV		0 mV	0 ns	0 mV
28					0 mV		0 mV	0 ns	0 mV
29					0 mV		0 mV	0 ns	0 mV
30					0 mV		0 mV	0 ns	0 mV
31					0 mV		0 mV	0 ns	0 mV

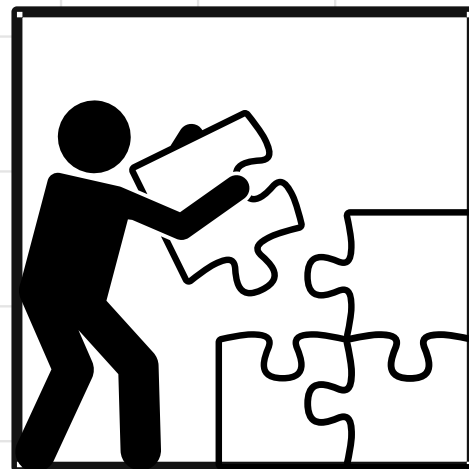
Umbral **300 DAC**  
 Ganancia **3 mv/fc**  
 Peak Time **200 ns**

Pulso de Prueba  
 Enmascarar Canales  
 Lógica Vecinos

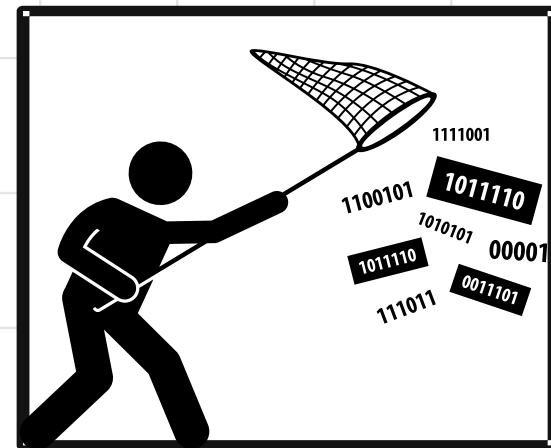
# Metodología



***Comprobar el funcionamiento.***



***Realizar el Montaje de los detectores GEM.***

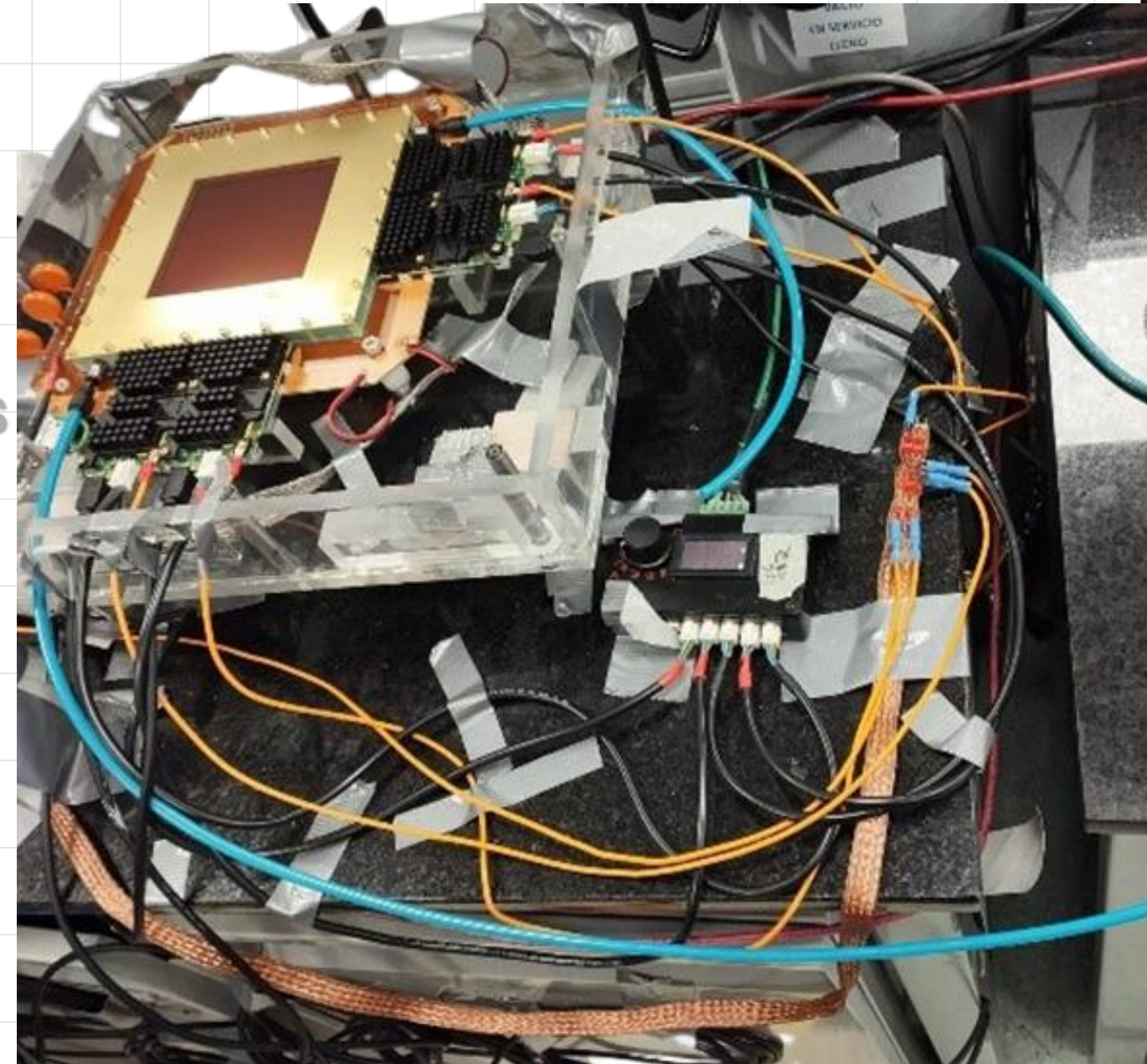


***Tomar datos con el Hodoscopio.***



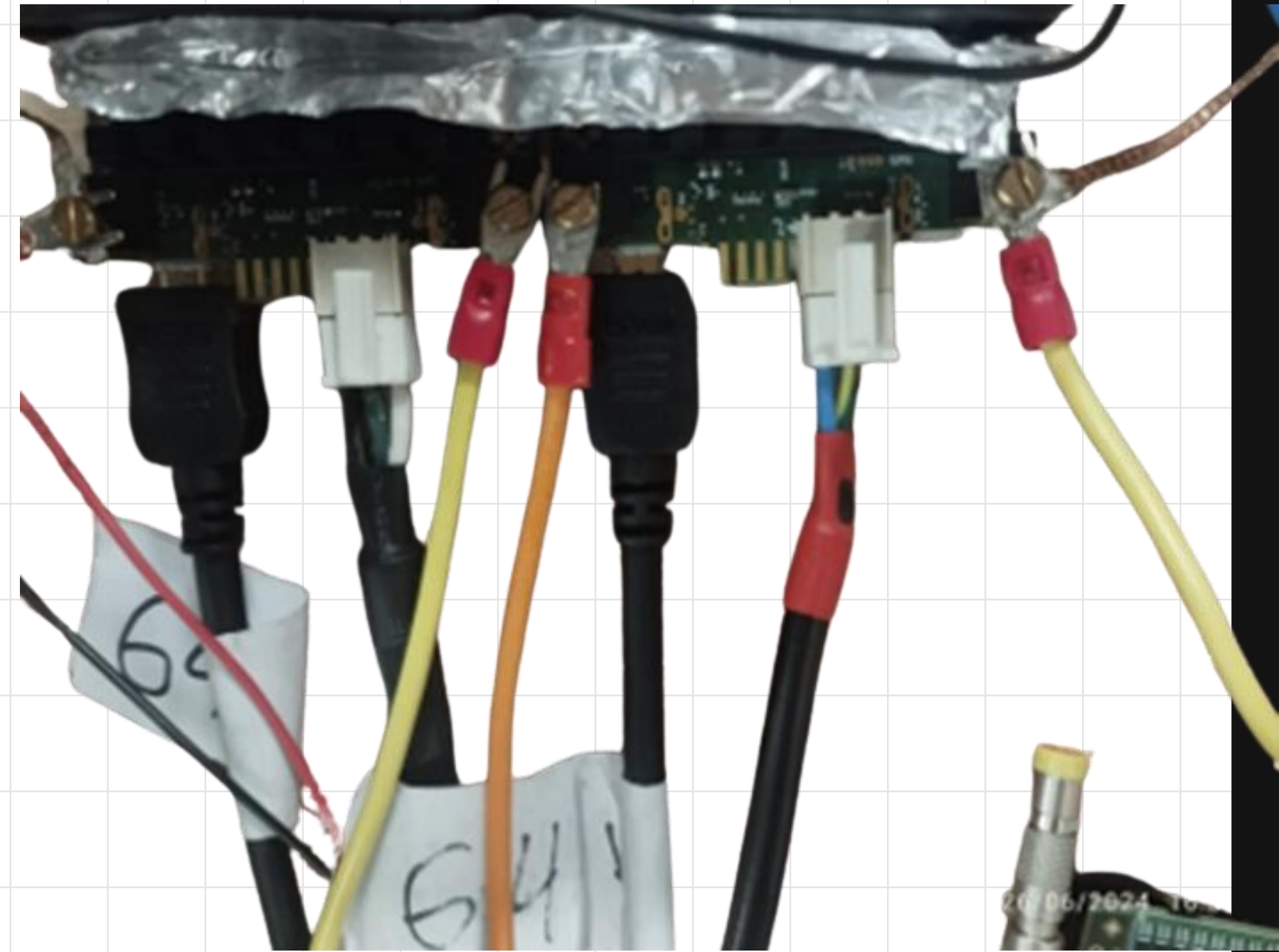
# Preparar el GEM

- **Purga del detector con Nitrógeno**  
Semanalmente antes de Usarlo  
Durante 1 hora con presión de 2-3 mbar
- **Instalación de las tarjetas Híbridas**  
Conexión cada tarjeta  
Cable tierra, alimentación y HDMI
- **Mejora de la Tierra por Ruidos**  
Tierra de Cobre  
Conexiones Hybrid-GEM



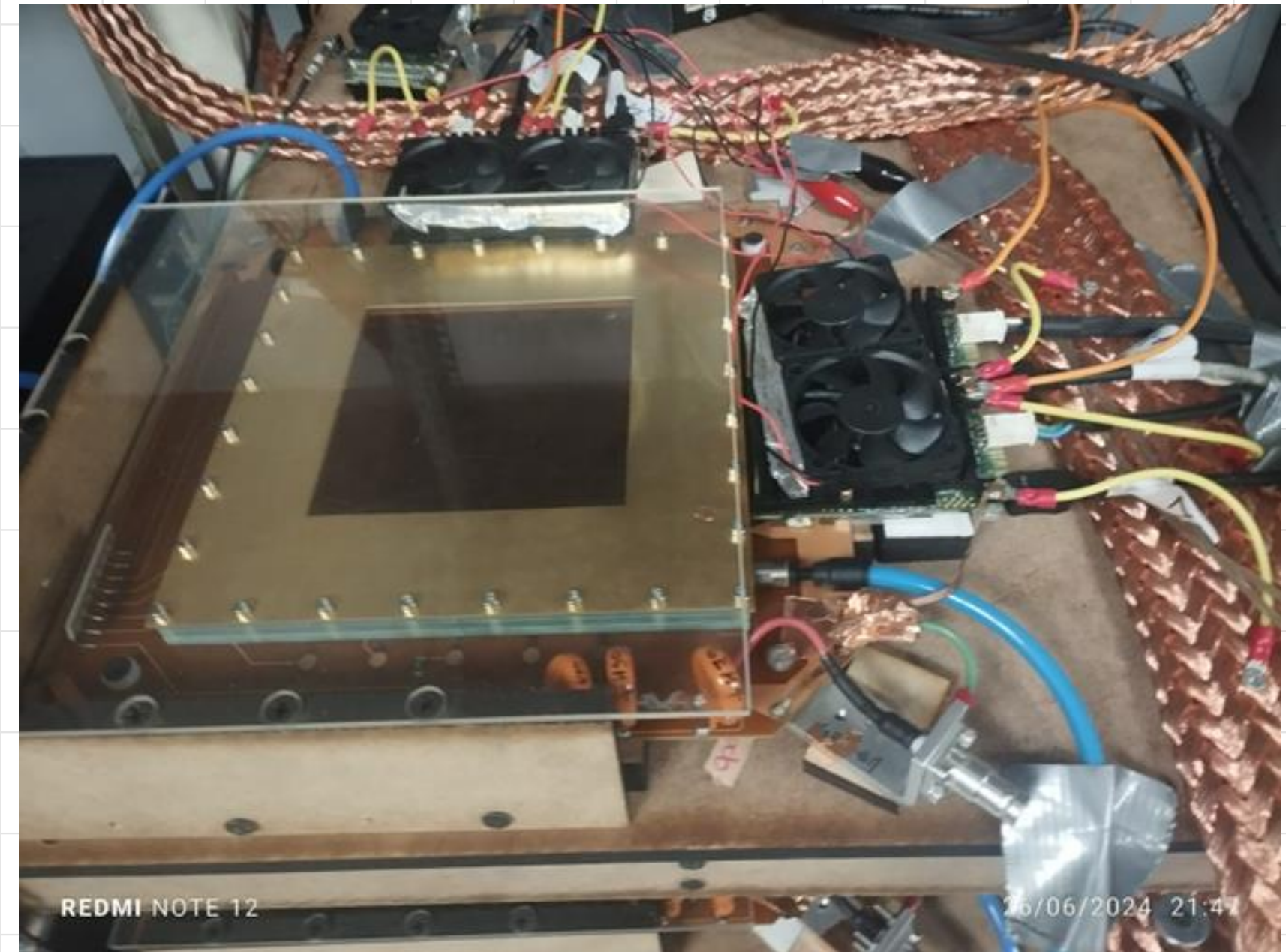
# Preparar el GEM

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Semanalmente antes de Usarlo  
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Cable tierra, alimentación y HDMI
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Tierra de Cobre  
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# Preparar el GEM

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Conexión cada tarjeta  
Cable tierra, alimentación y HDMI
- **Mejora de la Tierra por Ruidos**  
Tierra de Cobre  
Conexiones Hybrid-GEM



# Operación

- **Validación SRS**

Se prende el equipo SRS CRATE

Se verifica las conexiones

- **Gas Argón CO2**

Se deja Fluir el Gas

5-7 mbar de presión

- **Rampa de Voltaje**

5-7 Voltios por segundo

Pasos de 500 V

The screenshot displays a control interface for two hybrid systems, Hybrid 1 and Hybrid 2. The interface is divided into two main sections: Hybrid 1 and Hybrid 2. Each section has a 'VMM' (Voltage Measurement Module) and an 'I2C' (Inter-Integrated Circuit) section. The 'VMM' section for Hybrid 1 shows two checkboxes, '1' and '2', both of which are checked. The 'Position' section for Hybrid 1 has a dropdown menu for 'Axis' set to 'Y' and a 'Position' field set to '1'. The 'I2C' section for Hybrid 1 has a dropdown menu for 'Hybrid ID' set to 'Hybrid 1', a text field containing the ID '93A000A0000091', and a 'Read' button. The 'VMM 1' and 'VMM 2' sections for Hybrid 2 are also visible, with 'VMM 1' showing 'General Settings' and 'Advanced Settings' tabs. The 'Advanced Settings' tab for VMM 1 shows 'Input charge polarity' set to 'negative', 'Analog (Channel) Monitor' set to 'Temperature sensor', 'Gain (sg)' set to '3.0 mV/fC', 'TAC Slop Adj (stc)' set to '60 ns', and 'Peak time (st)' set to '200 ns'. The 'ReadADC' button is highlighted, showing a reading of '49.1892 °C'. The 'SRAT Mode' is set to 'Timing At Peak'. There are also buttons for 'Neighbor Trigger (sng)', 'Disable At Peak', 'Analog tristates', and 'Sub Hysterisis'.

# Operación

- **Validación SRS**  
Se prende el equipo SRS CRATE  
Se verifica las conexiones
- **Gas Argón CO2**  
Se deja Fluir el Gas  
5-7 mbar de presión
- **Rampa de Voltaje**  
5-7 Voltios por segundo  
Pasos de 500 V

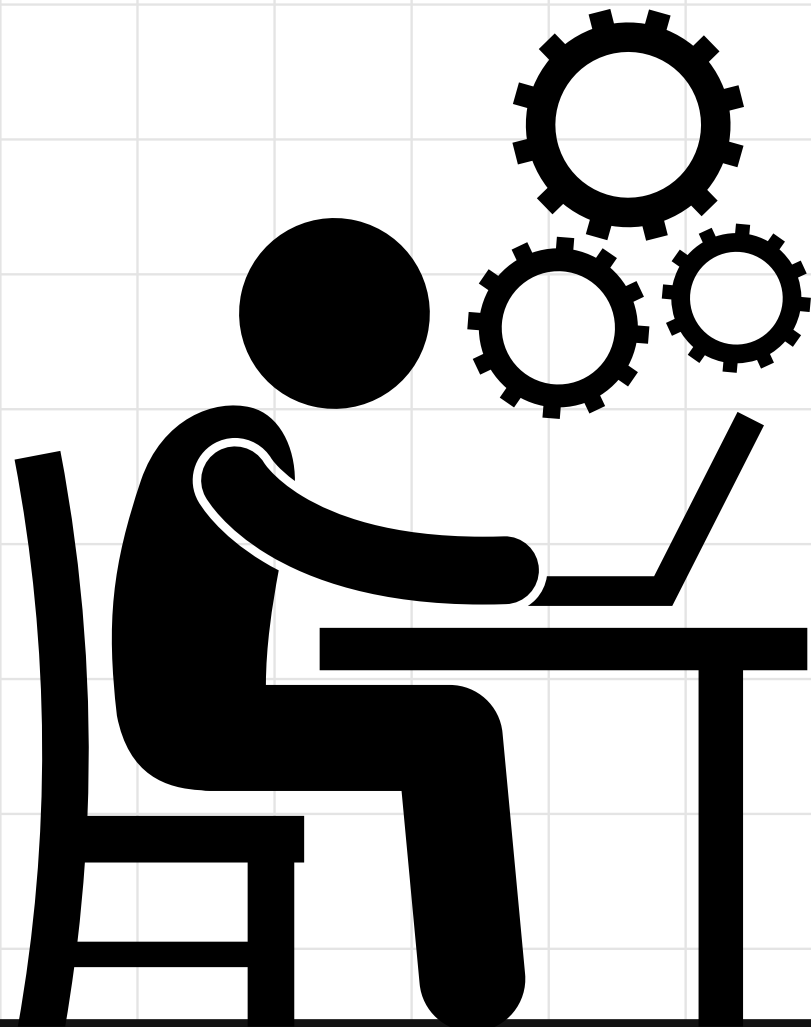


# Operación

- **Validación SRS**  
Se prende el equipo SRS CRATE  
Se verifica las conexiones
- **Gas Argón CO2**  
Se deja Fluir el Gas  
5-7 mbar de presión
- **Rampa de Voltaje**  
5-7 Voltios por segundo  
Pasos de 500 V



# ¿El Sistema Funciona?



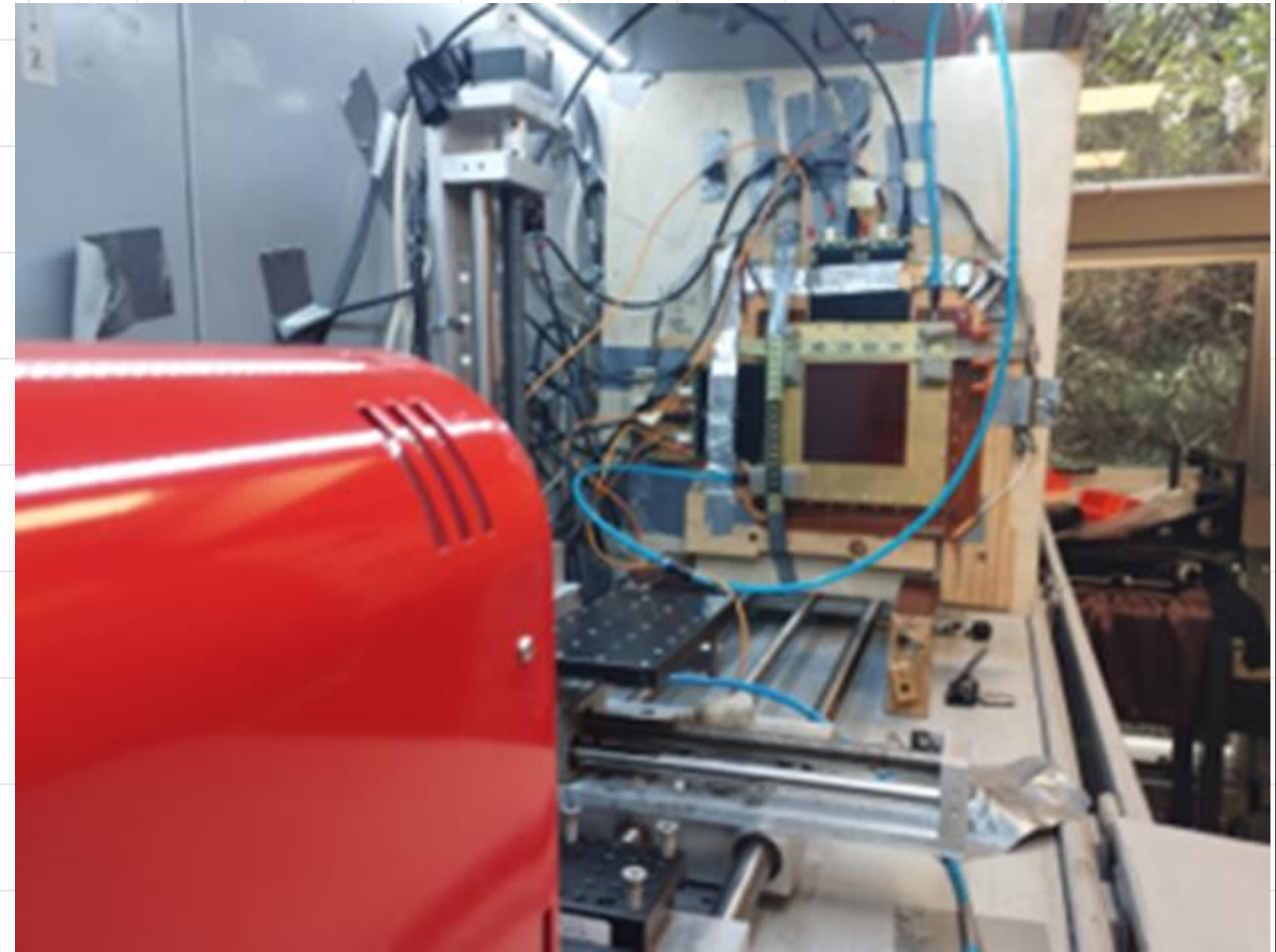
# Rayos X

**Fuente de 130 kV MICROFOCUS X-RAY**

**Voltajes de 21, 30, 45, 60 kV**

**Corriente de 1  $\mu$ A**

**Se realizó las correcciones de Campo Plano**

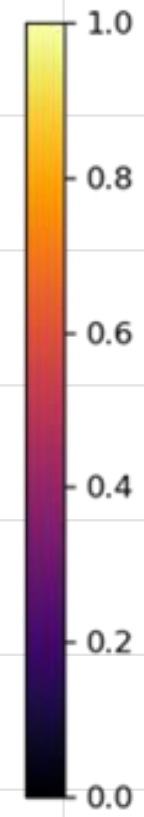
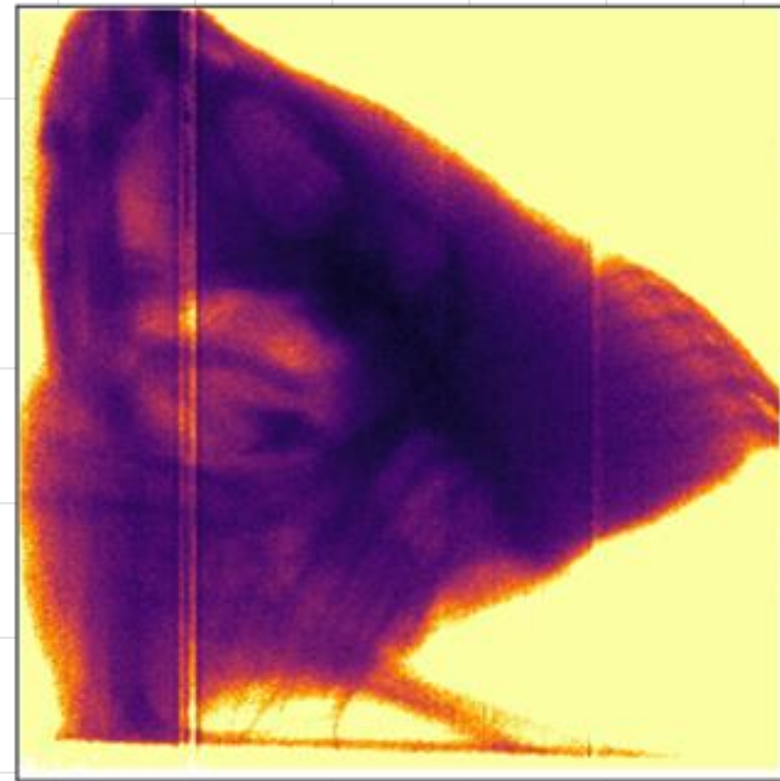


86 cm

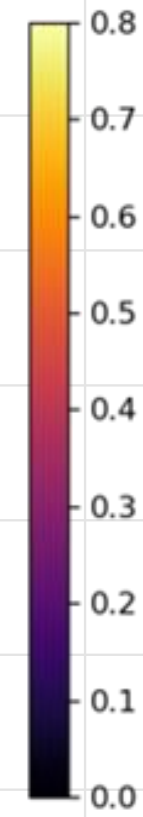
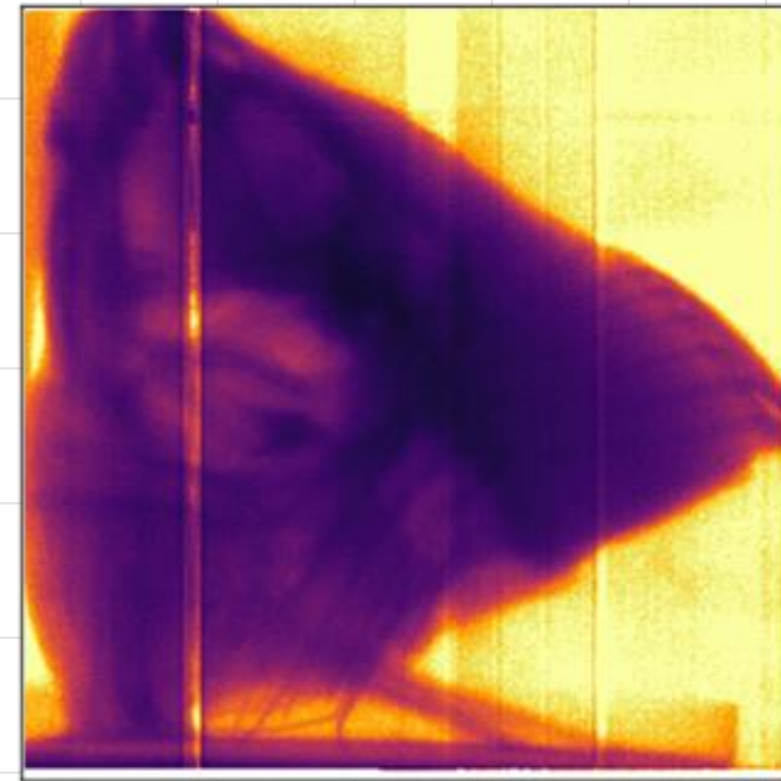




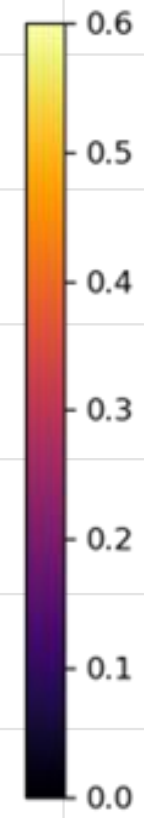
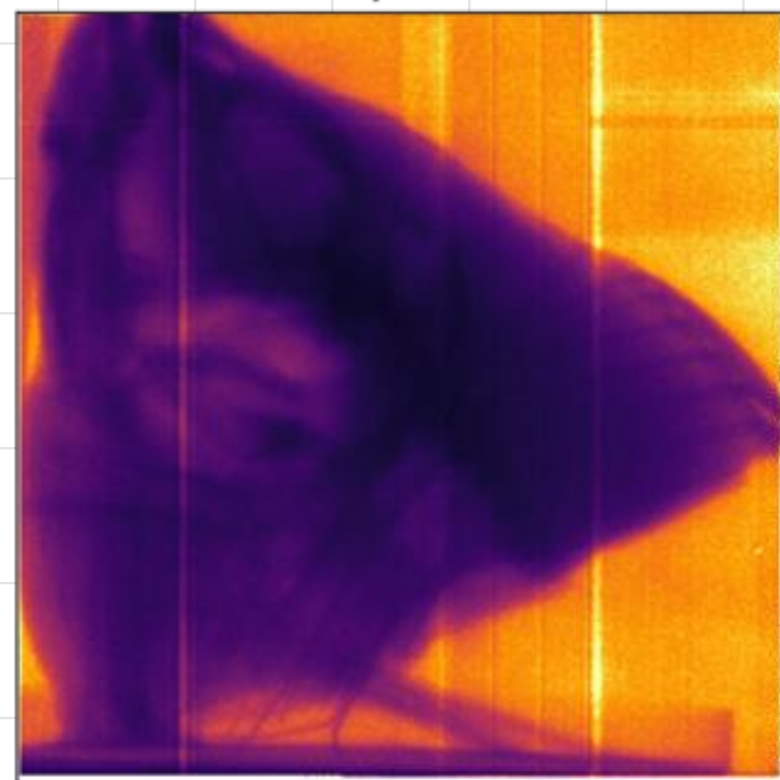
Voltaje 21 kV



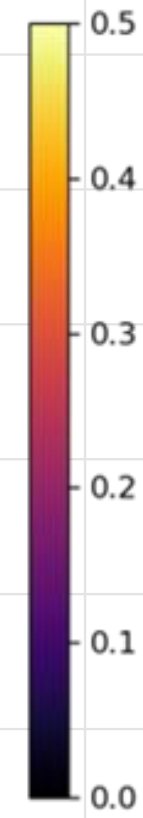
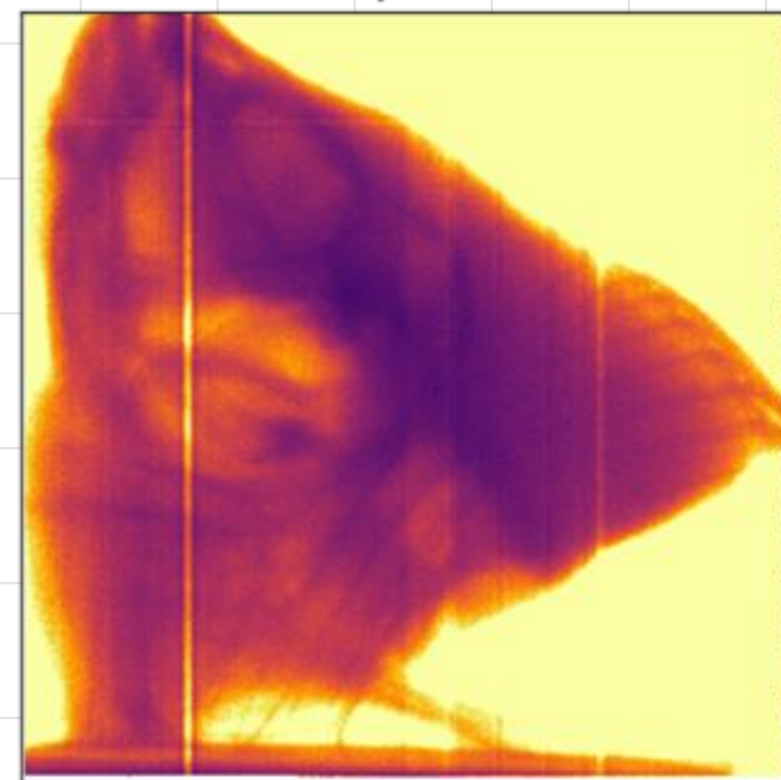
Voltaje 30 kV

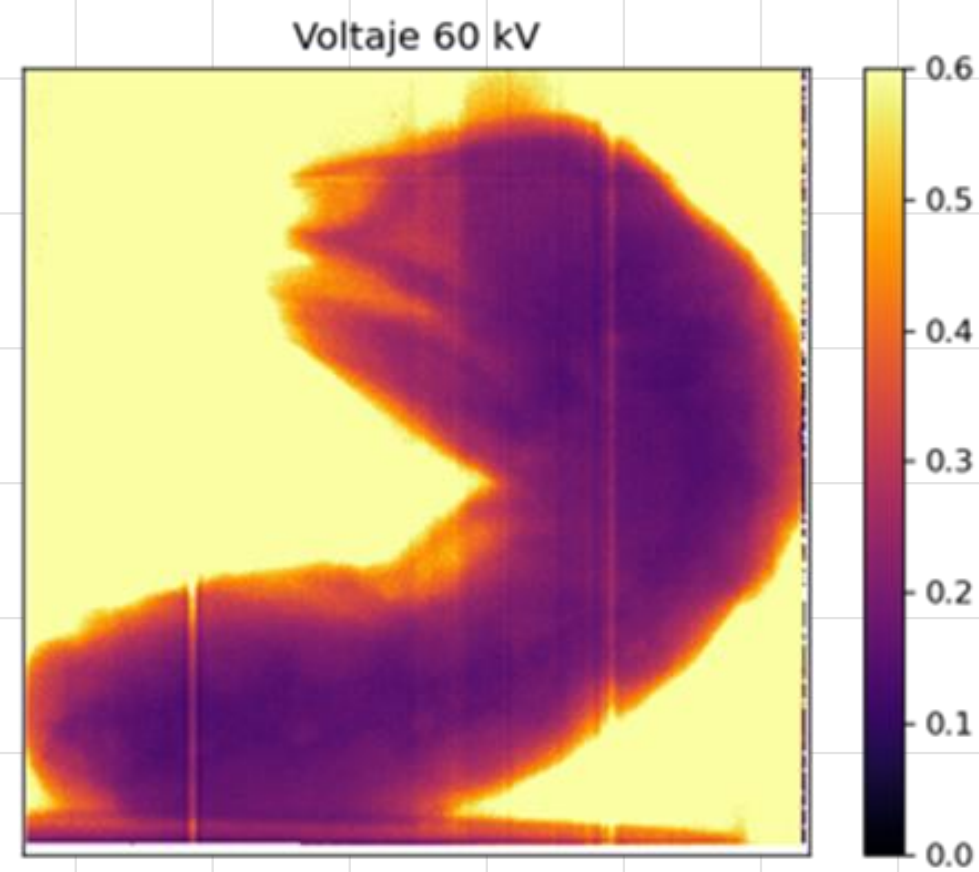
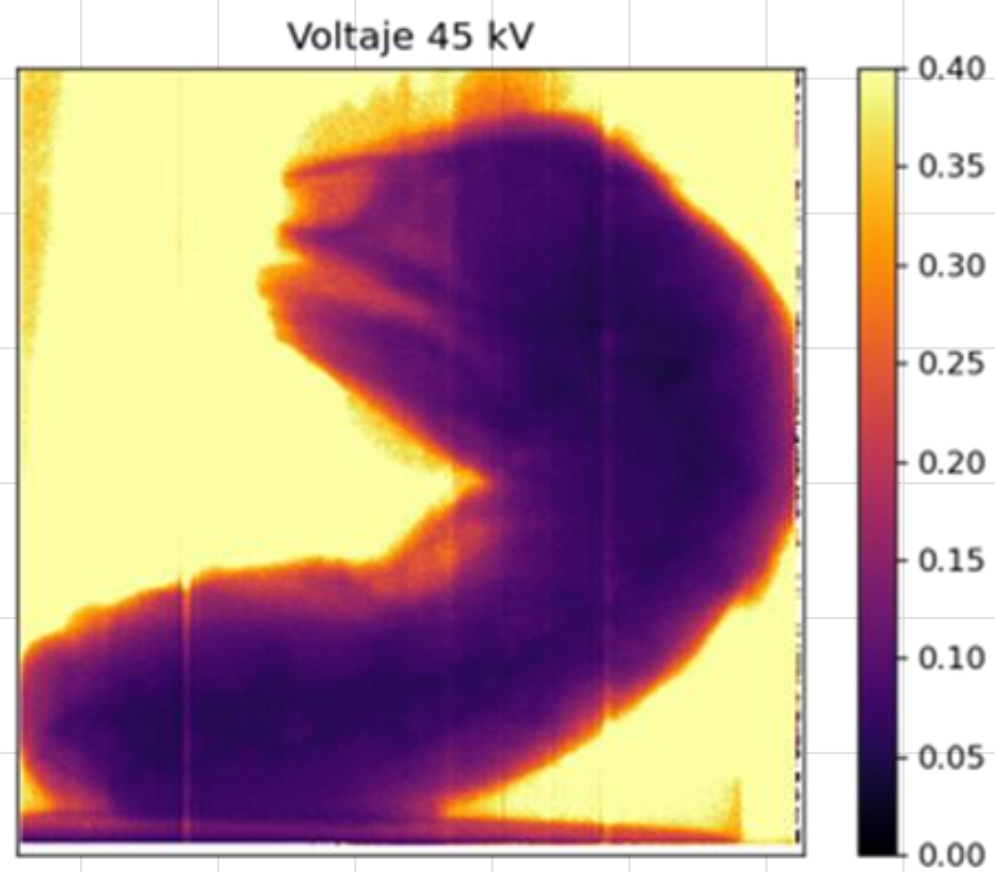
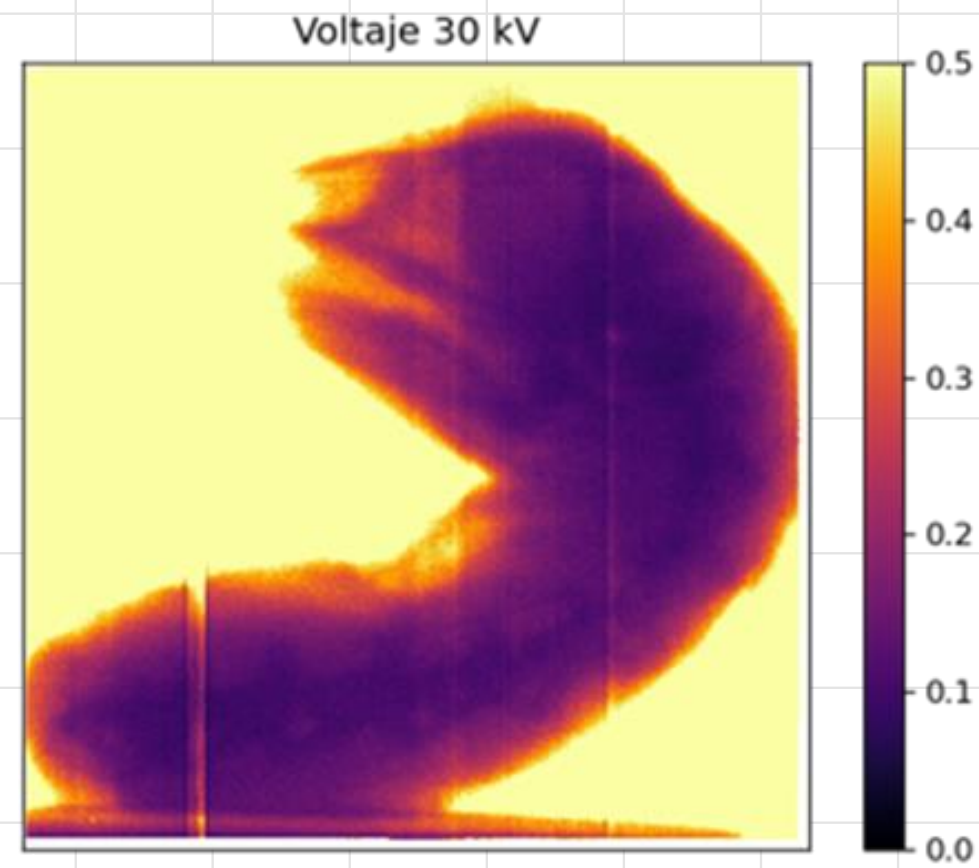
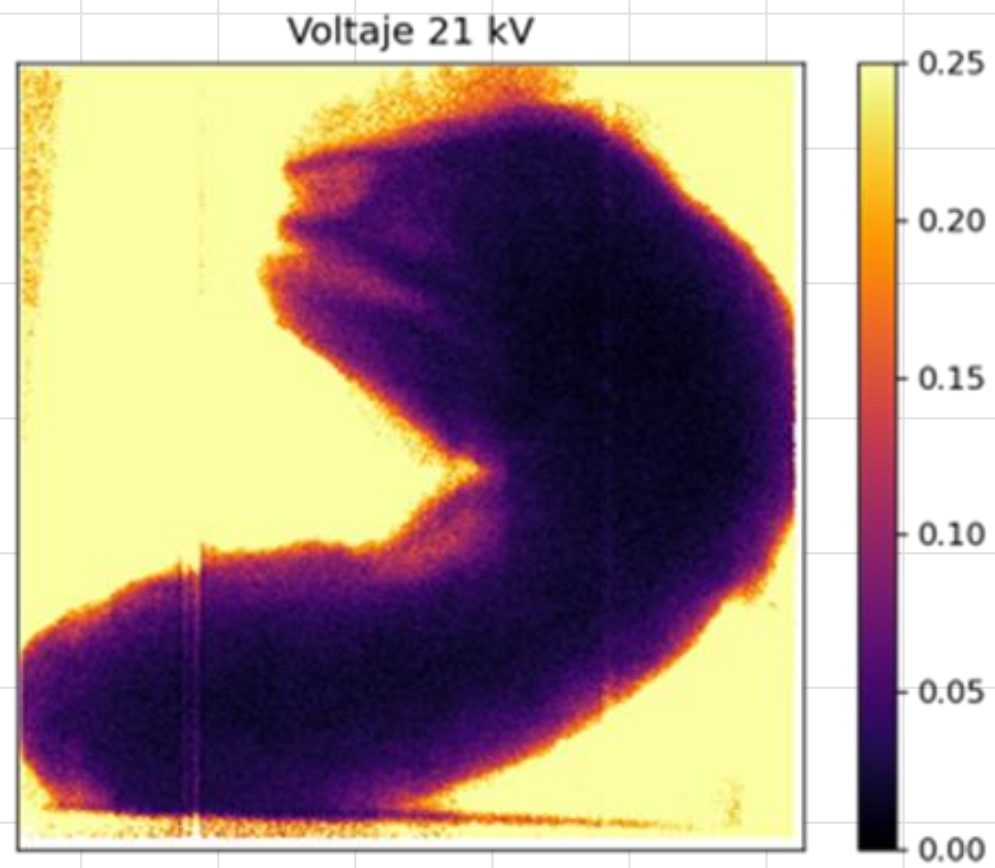


Voltaje 45 kV

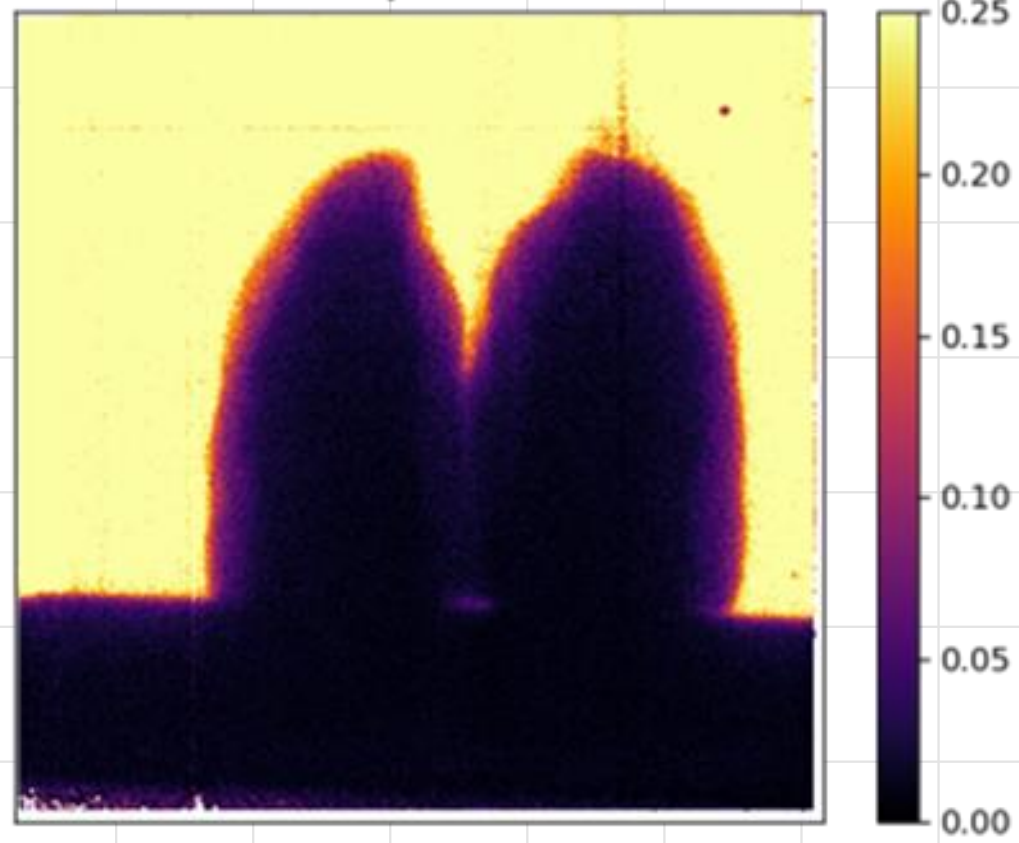


Voltaje 60 kV

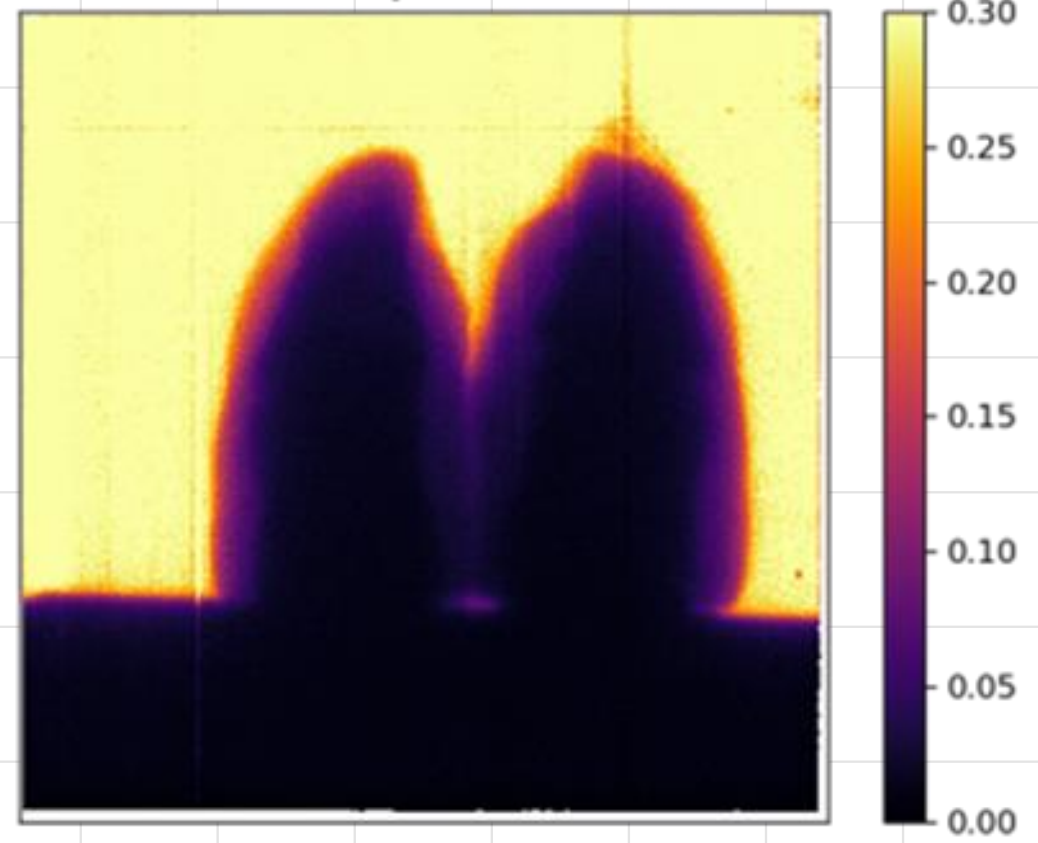




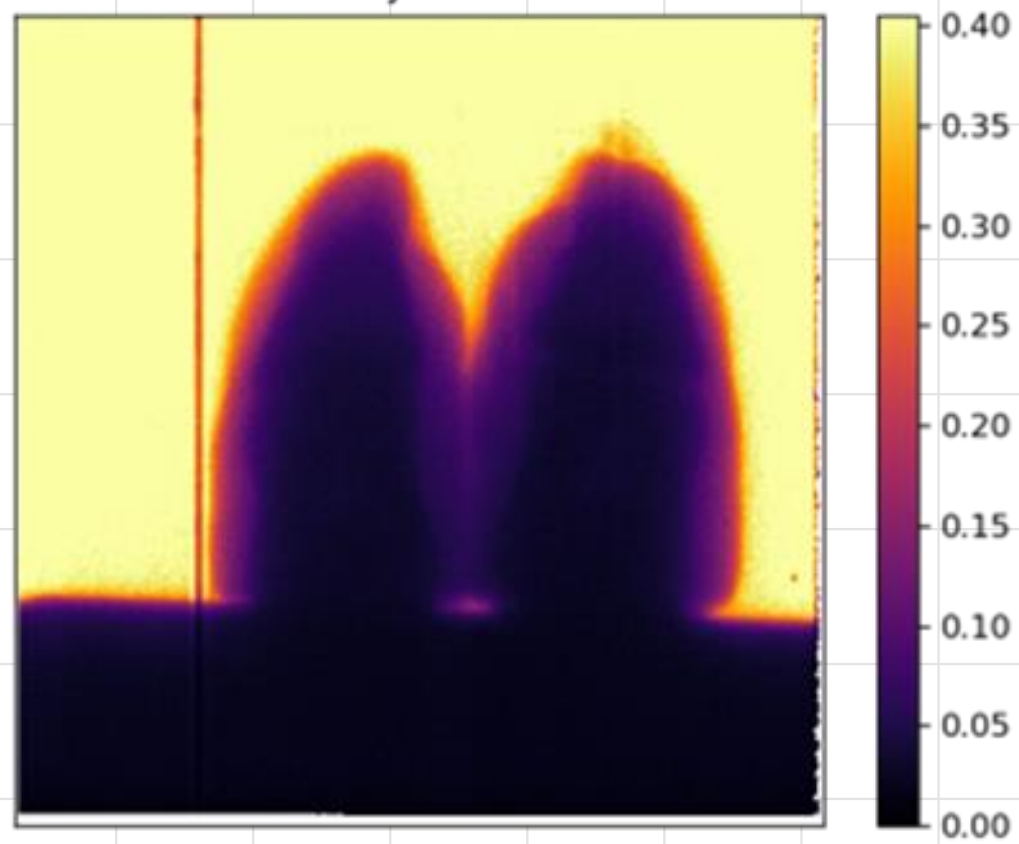
Voltaje 21 kV



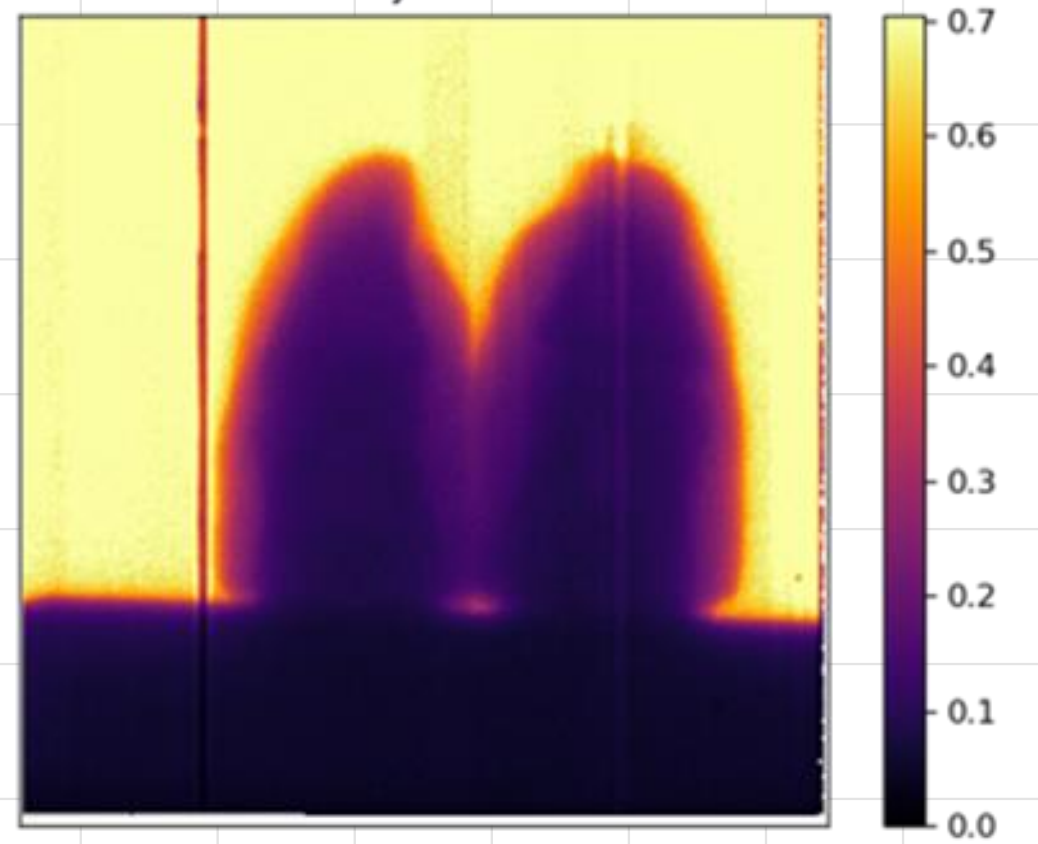
Voltaje 30 kV



Voltaje 45 kV

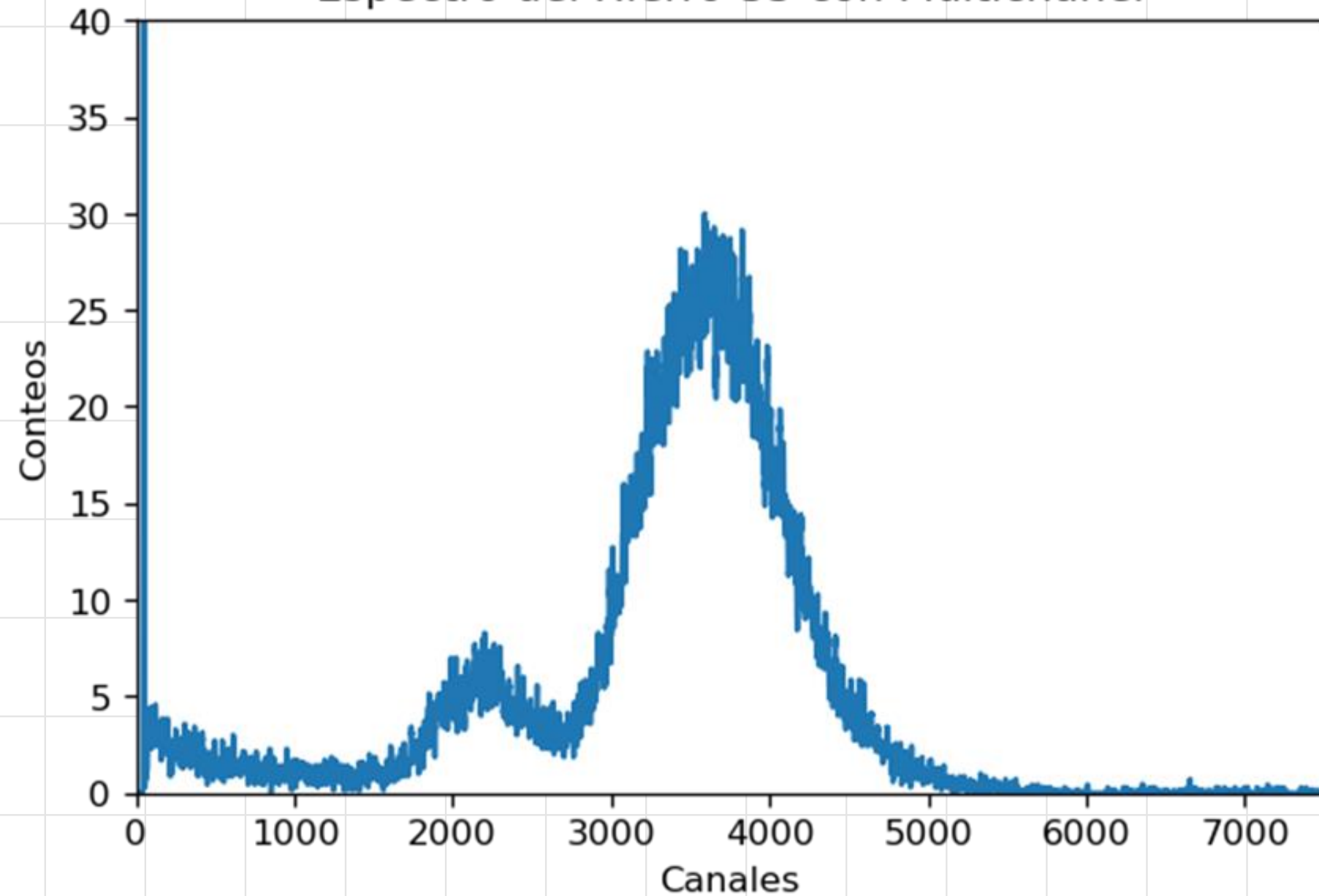


Voltaje 60 kV

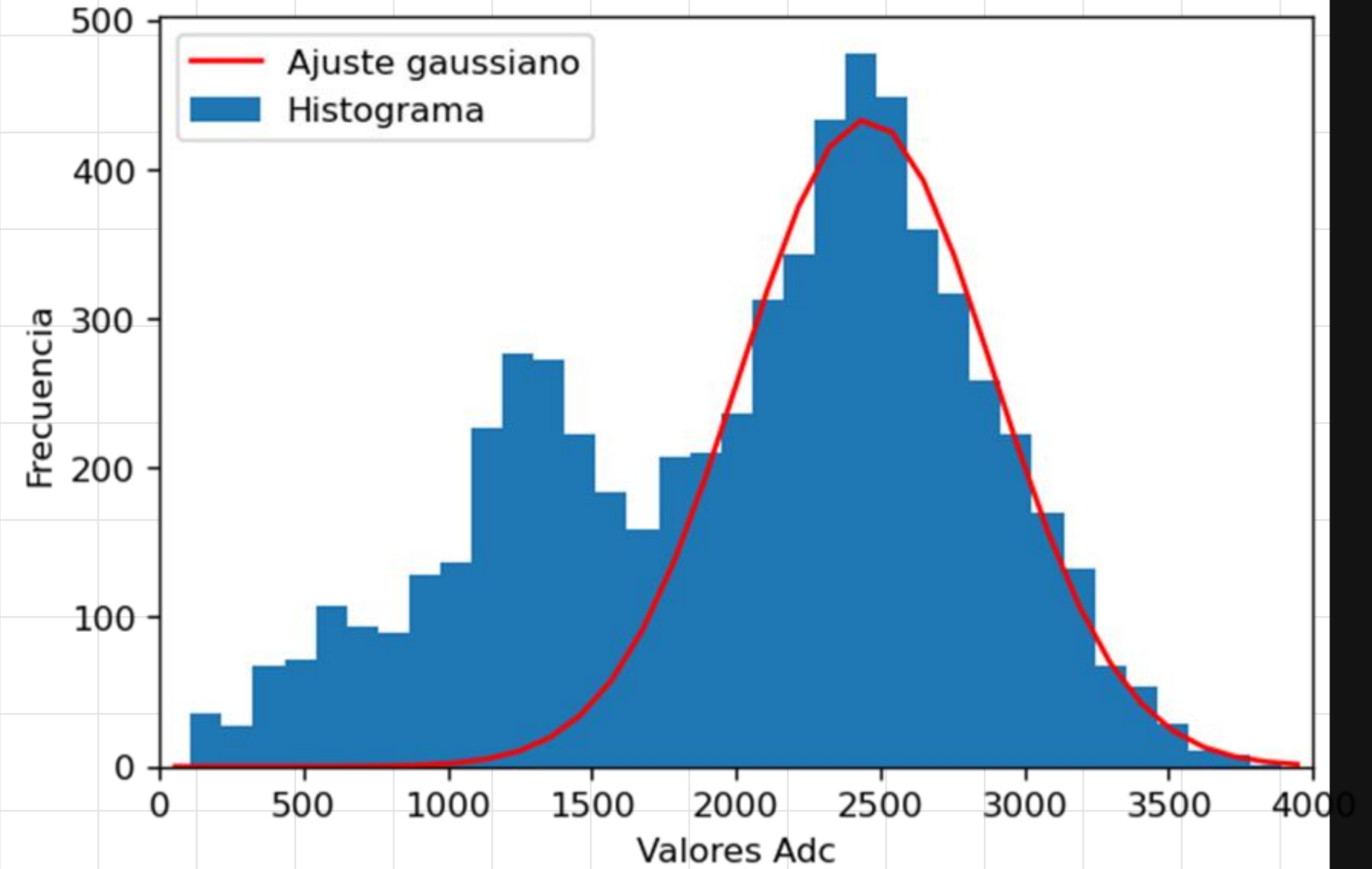


# Fuente Radiactiva Fe55

Espectro del Hierro-55 con Multichanel

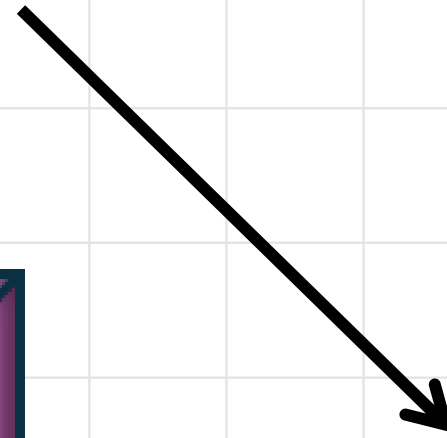
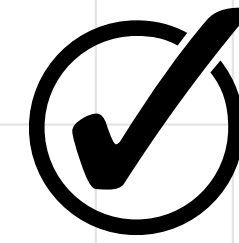


GEM 4



$$\sigma = (17.9 \pm 0.6)\%$$

# Funciona

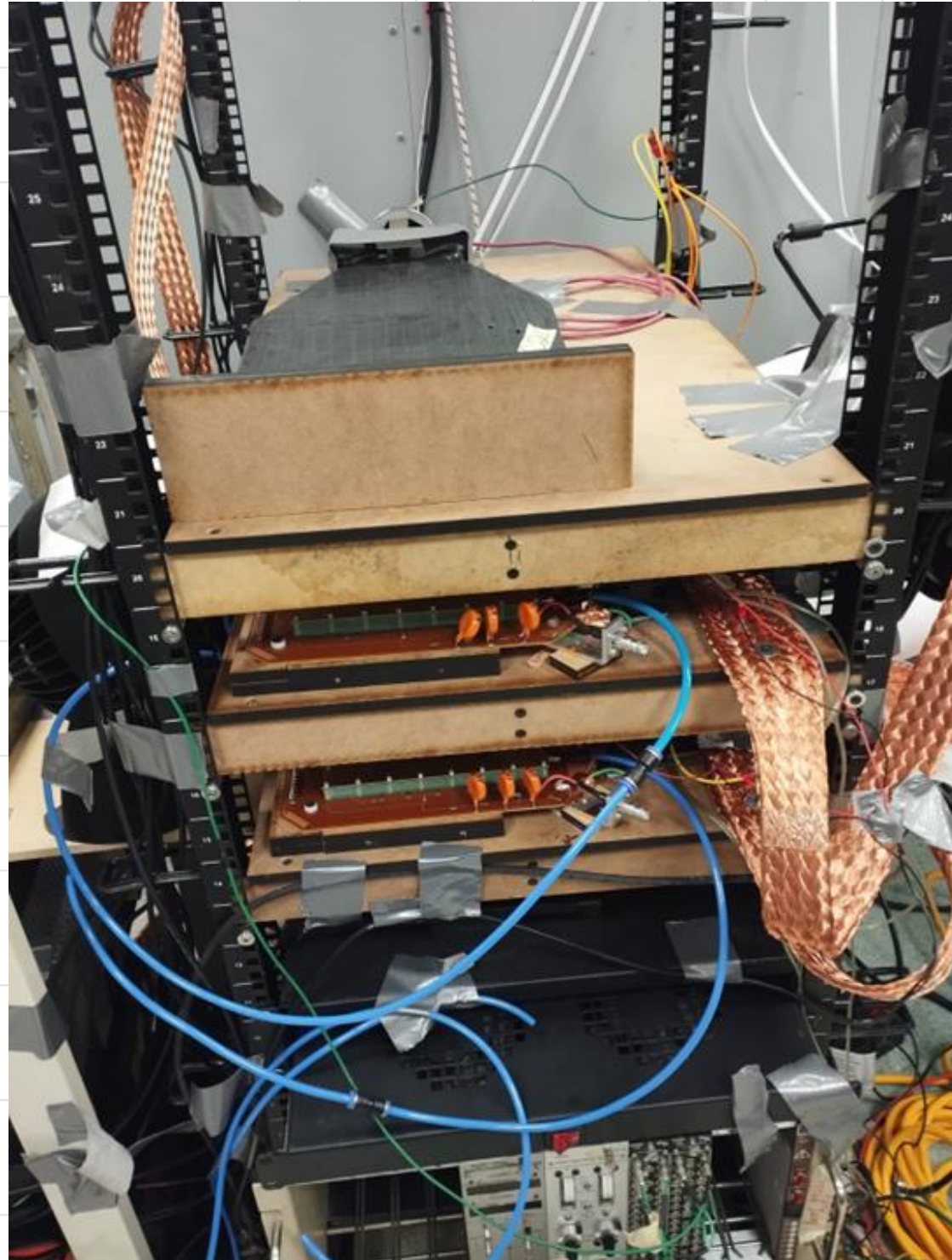


105.7  $MeV/c^2$   
-1  
2.2  
 $\mu s$   
 $\mu$   
muon

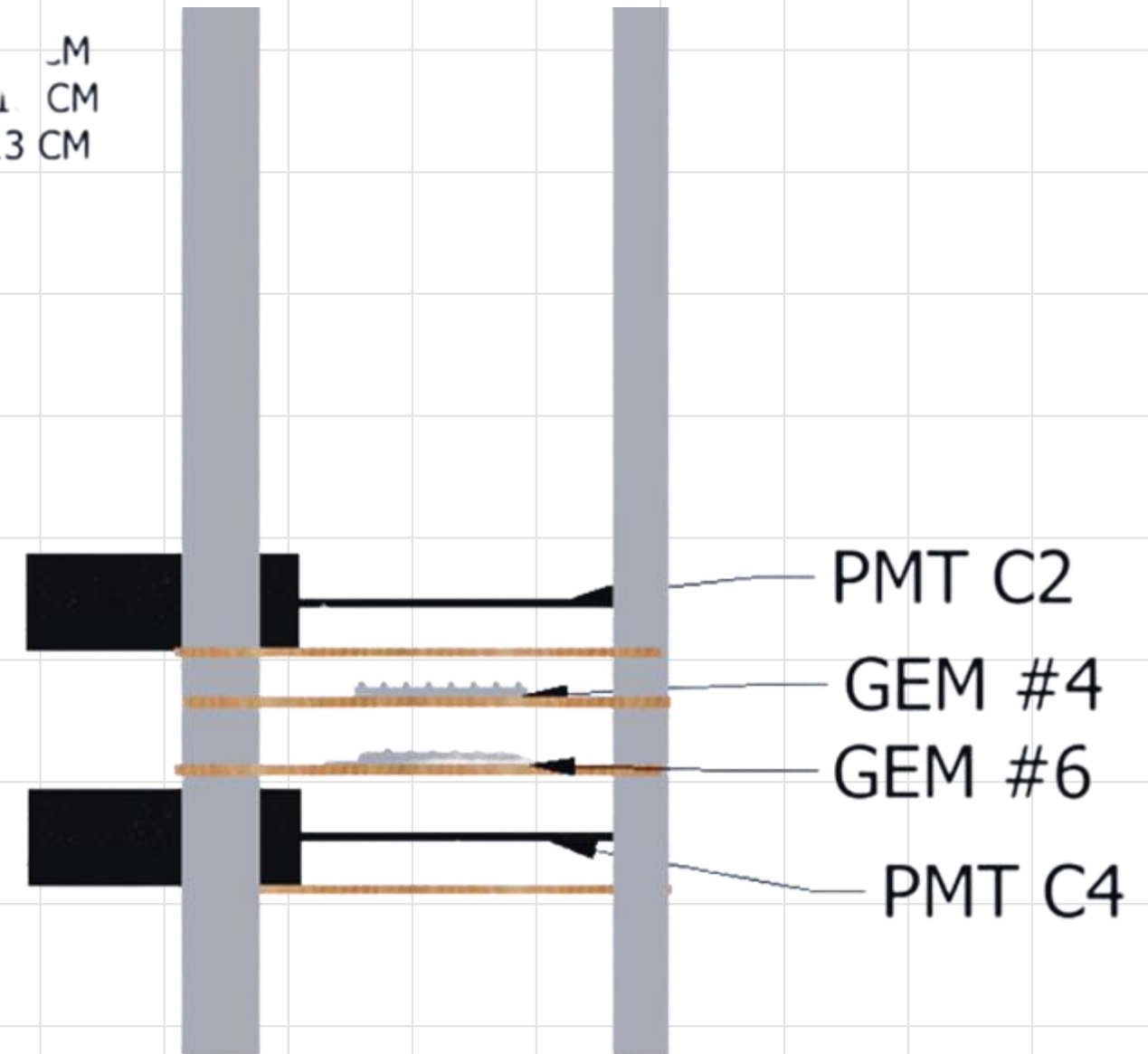
A 3D pink rectangular box with a dark blue outline. Inside the box, the following text is displayed: '105.7 MeV/c<sup>2</sup>' at the top, '-1' below it, '2.2' below that, and ' $\mu s$ ' at the bottom left. In the center of the box is a large Greek letter ' $\mu$ ', and at the bottom center is the word 'muon'.

# *Muones*

# Montaje de Muones

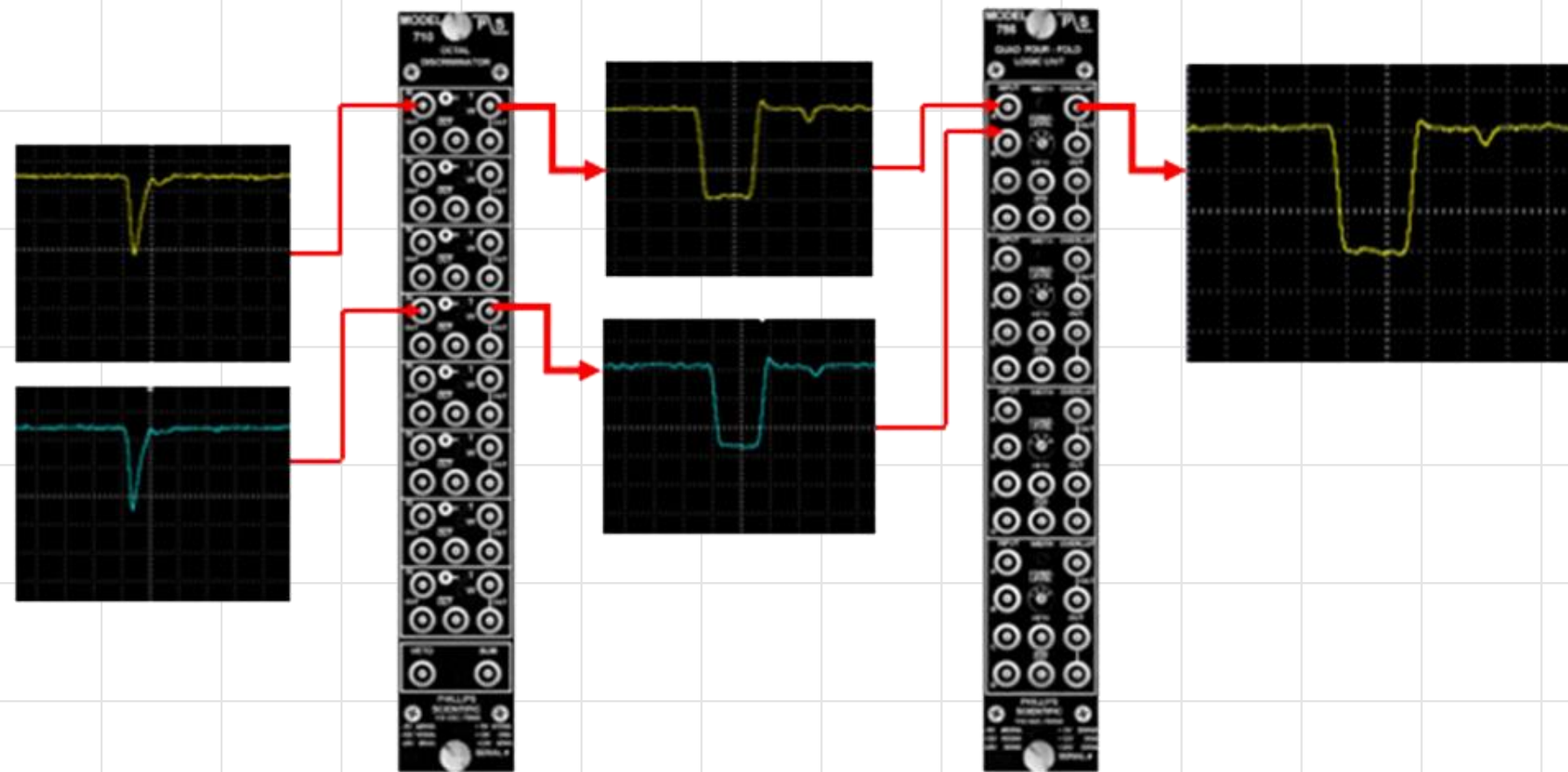


$\mu$   
D 1 CM  
D=13 CM



# Preparación PMT

*PMT de 25x25 cm<sup>2</sup>  
Voltaje de Operación -2000 V*



*Umbral: 100 mV*

*Ventana Temporal: 20-25 ns*



# Muones

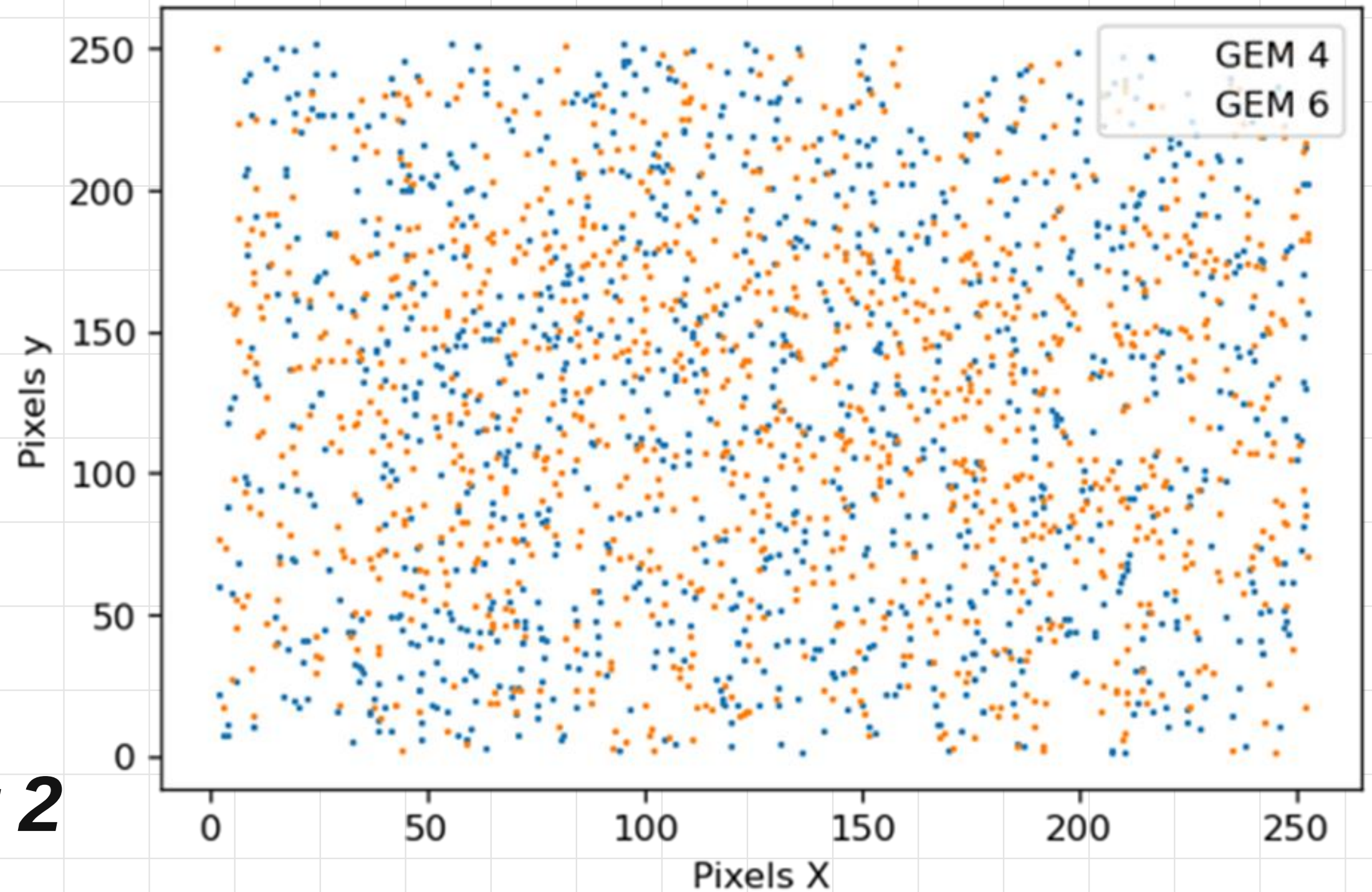
***Coincidencia Triple***

***Señal del Trigger***

***$dt < 500 \text{ ns}$***

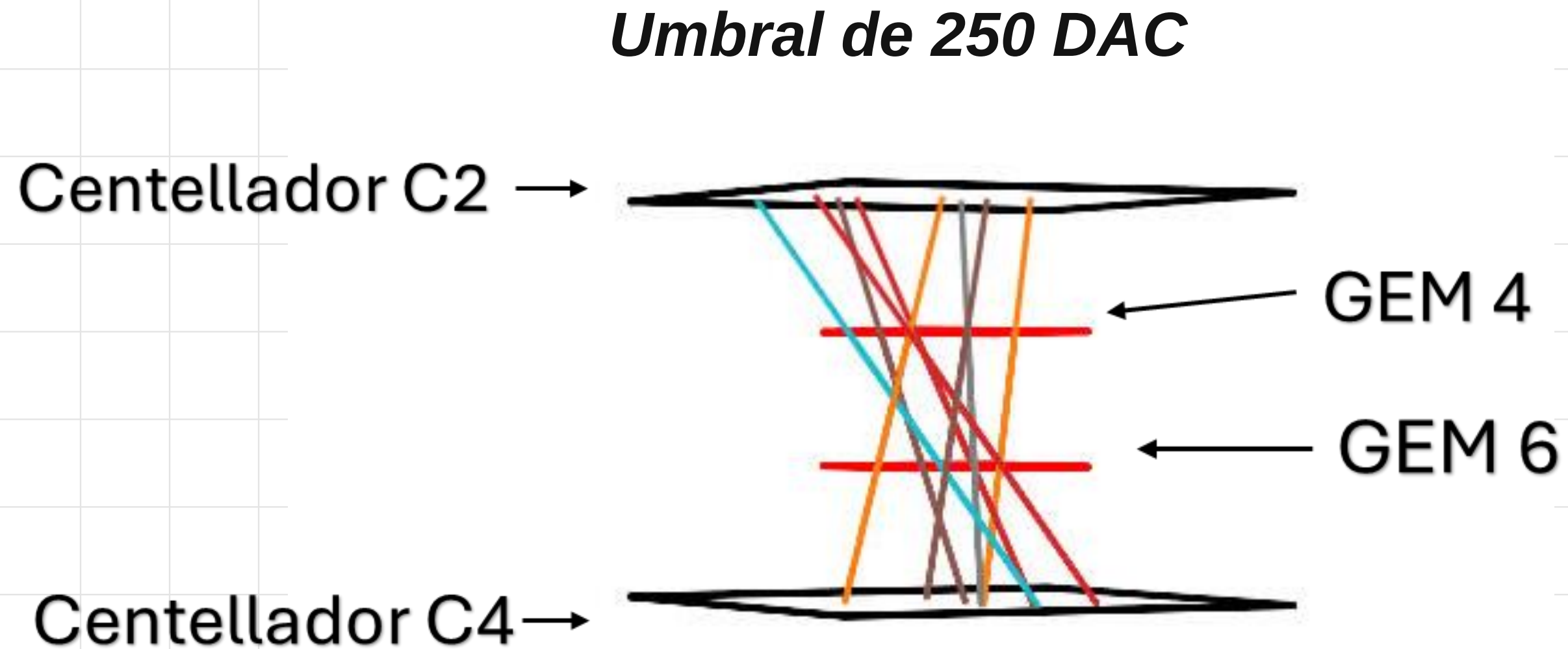
***Detector 1***

***Detector 2***



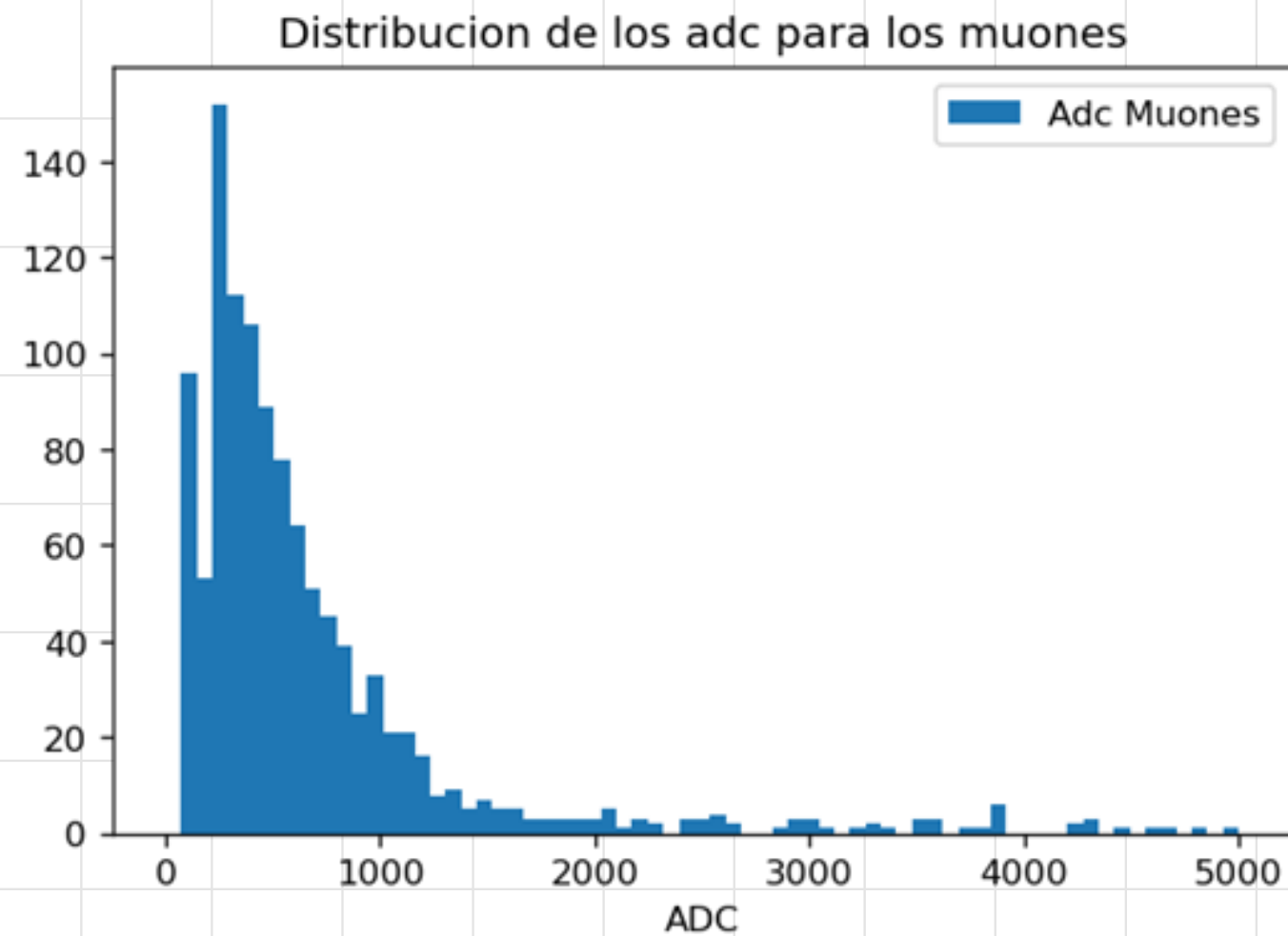
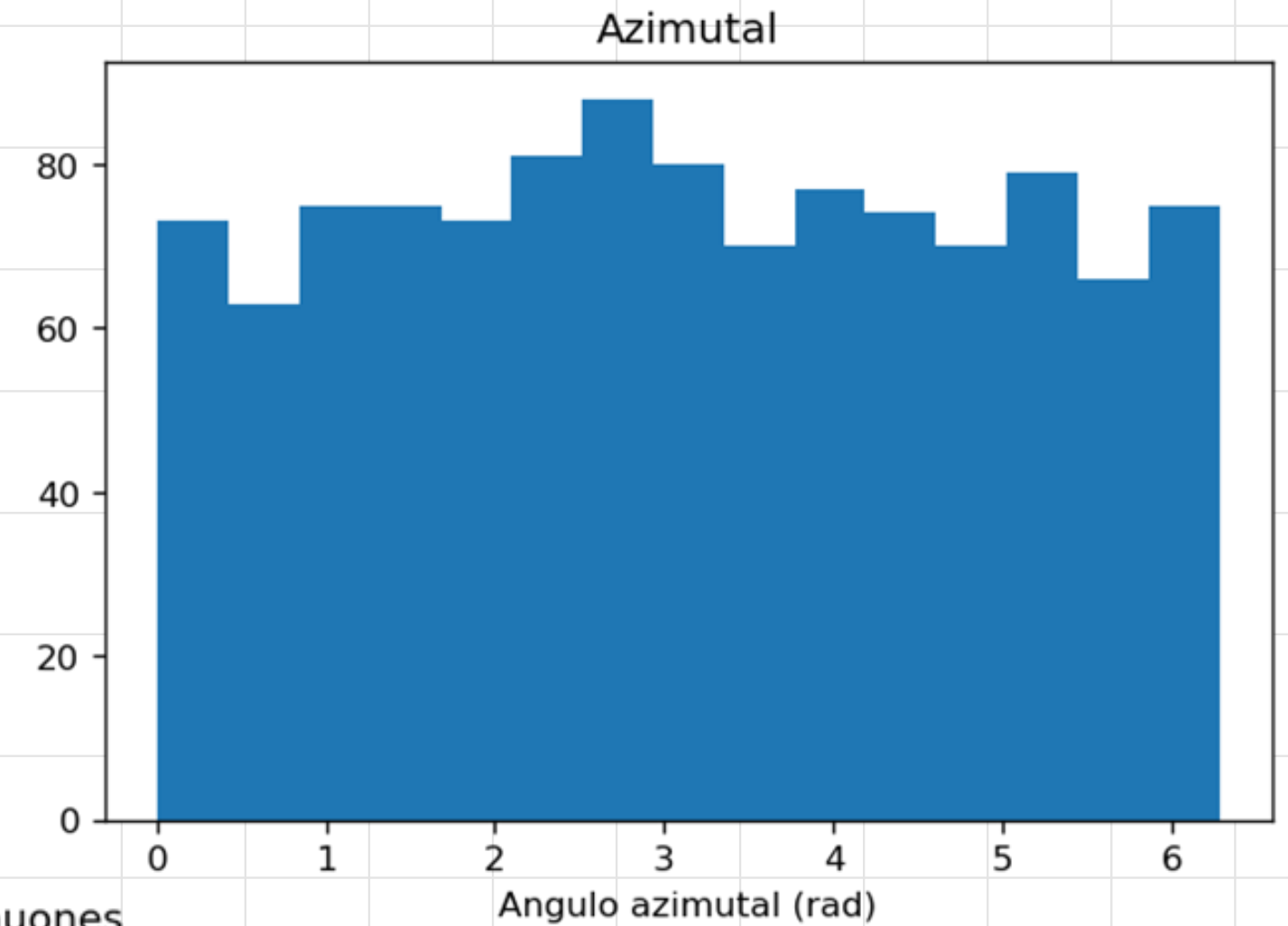
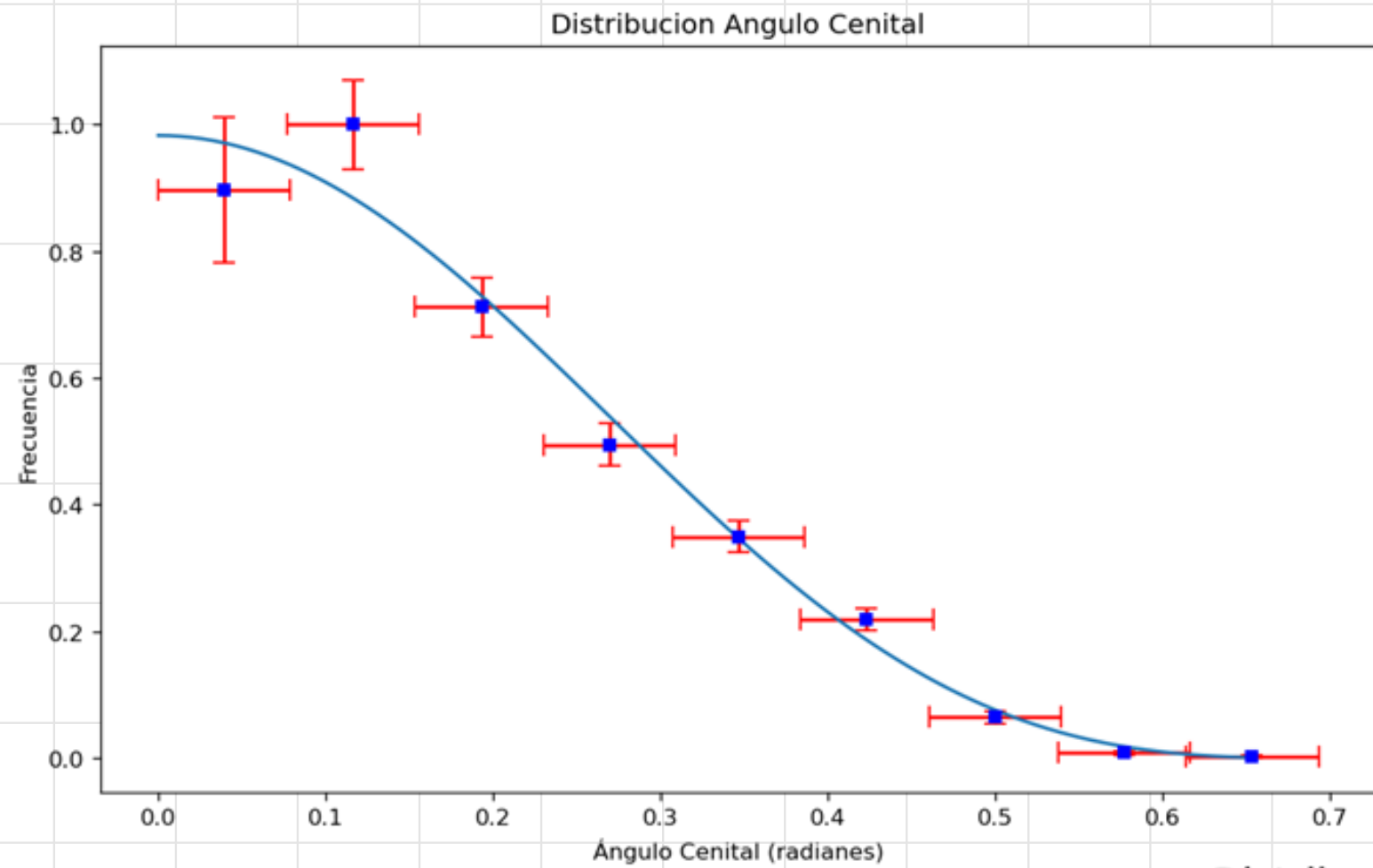


# Reconstrucción

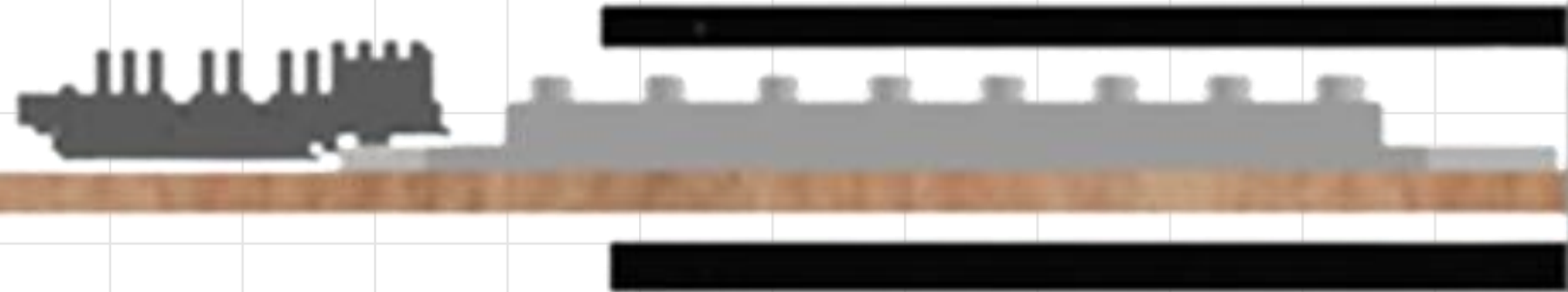
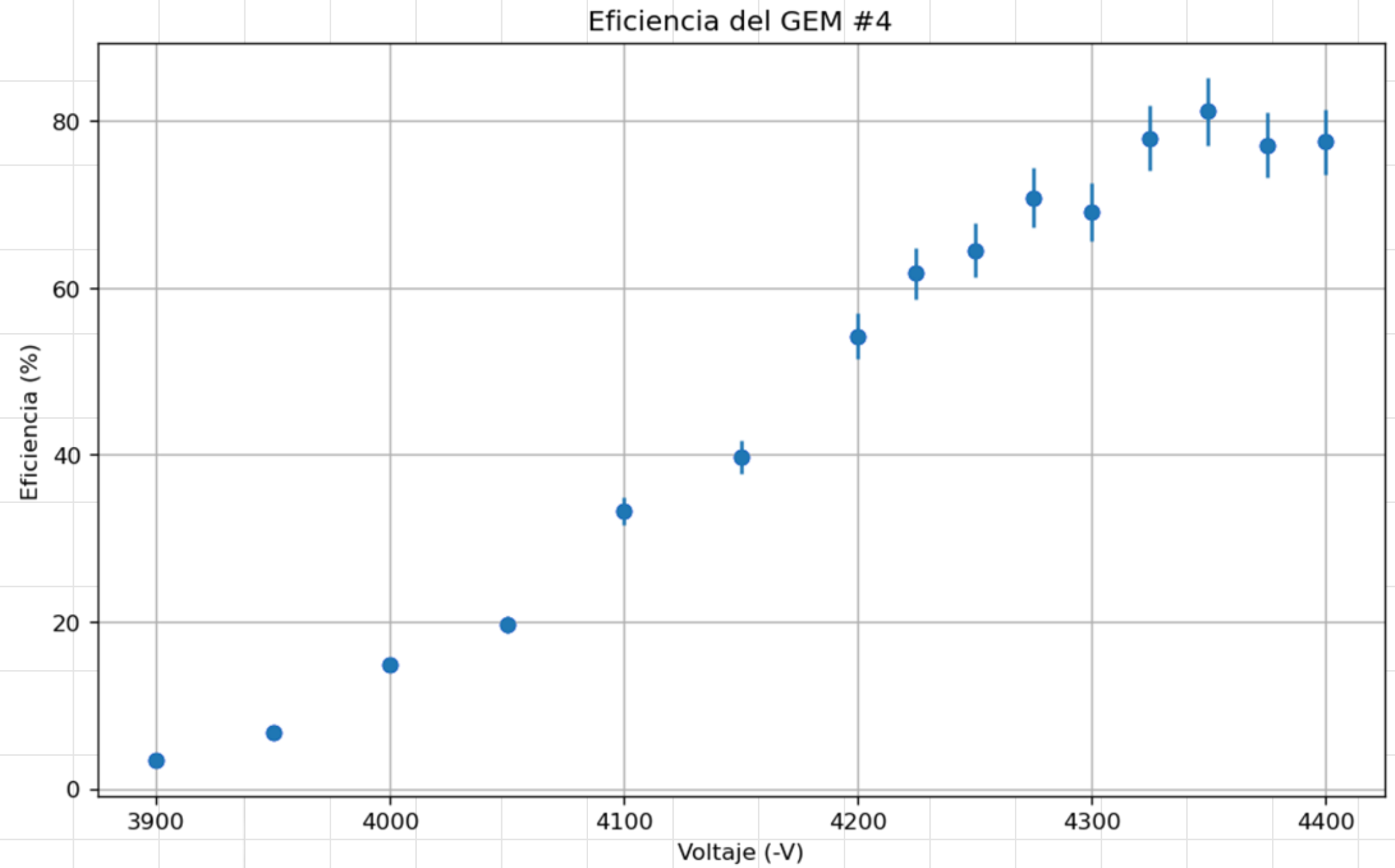


***1119 Coincidencias Triples***  
***31498 Señales PMT***

# Muones

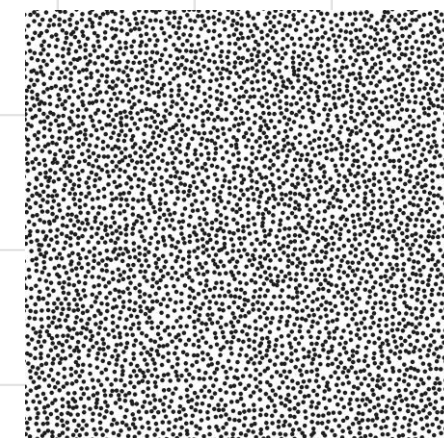
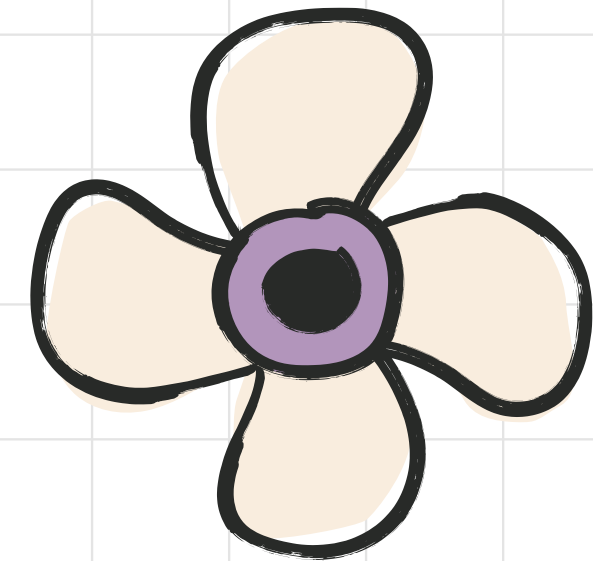


# Eficiencia



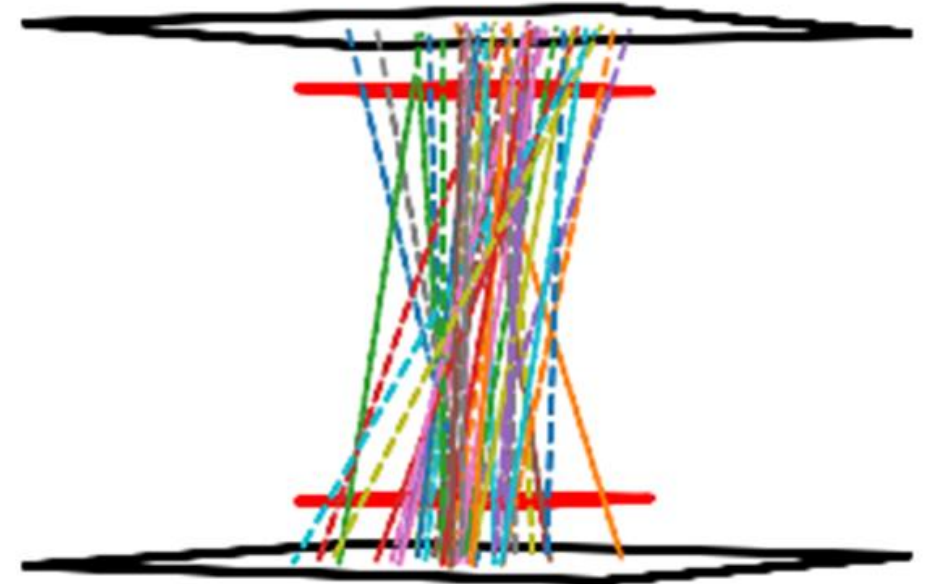
# Problemas Técnicos

- *Baja eficiencia en la reconstrucción de los muones.*
- *Poder recircular el gas ArCO<sub>2</sub>*
- *Mejorar la ventilación de las tarjetas Híbridas*
- *Disminuir el ruido del sistema*

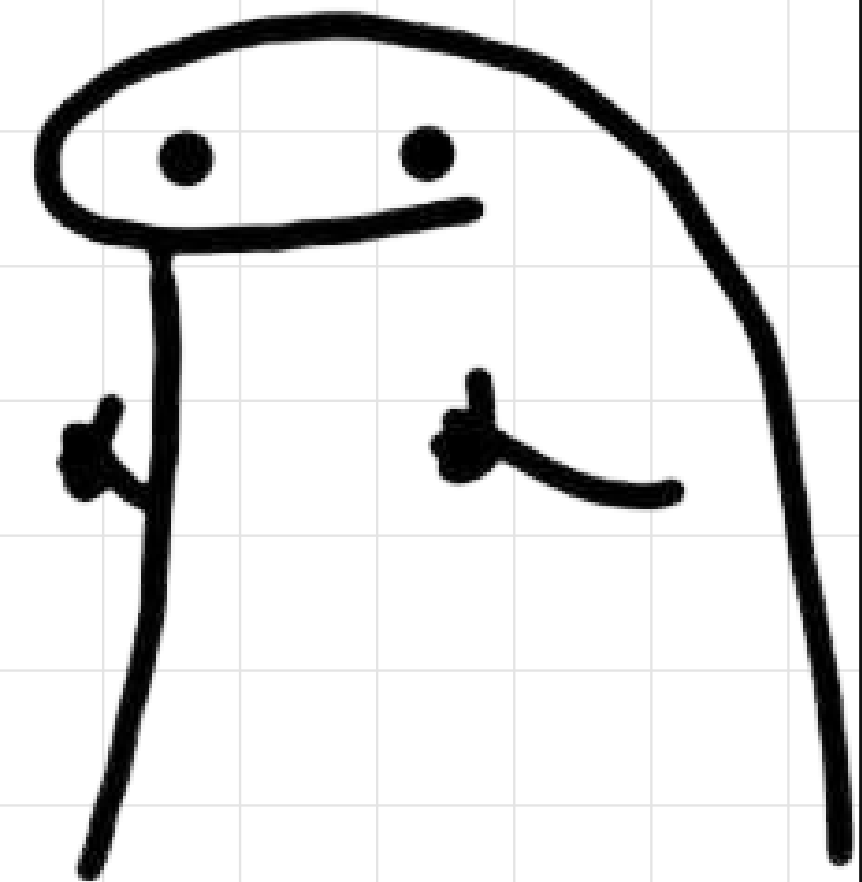


# Conclusiones

- ***Se comprobó el funcionamiento del sistema GEM-SRS.***
- ***Se obtuvieron imágenes de rayos X para muestras biológicas.***
- ***Se obtuvieron las trayectorias de muones con el sistema de adquisición de datos.***



# Muchas Gracias!

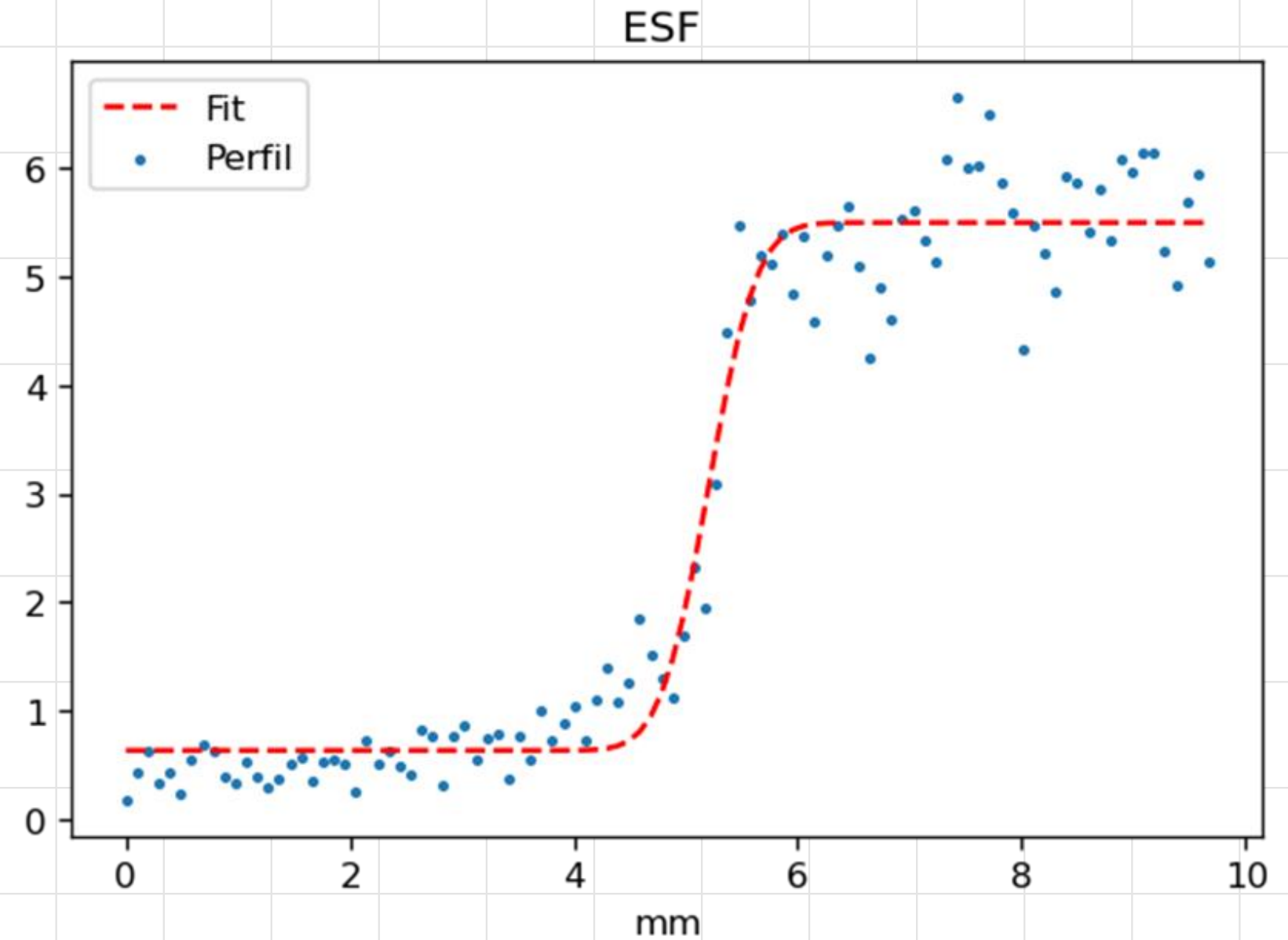
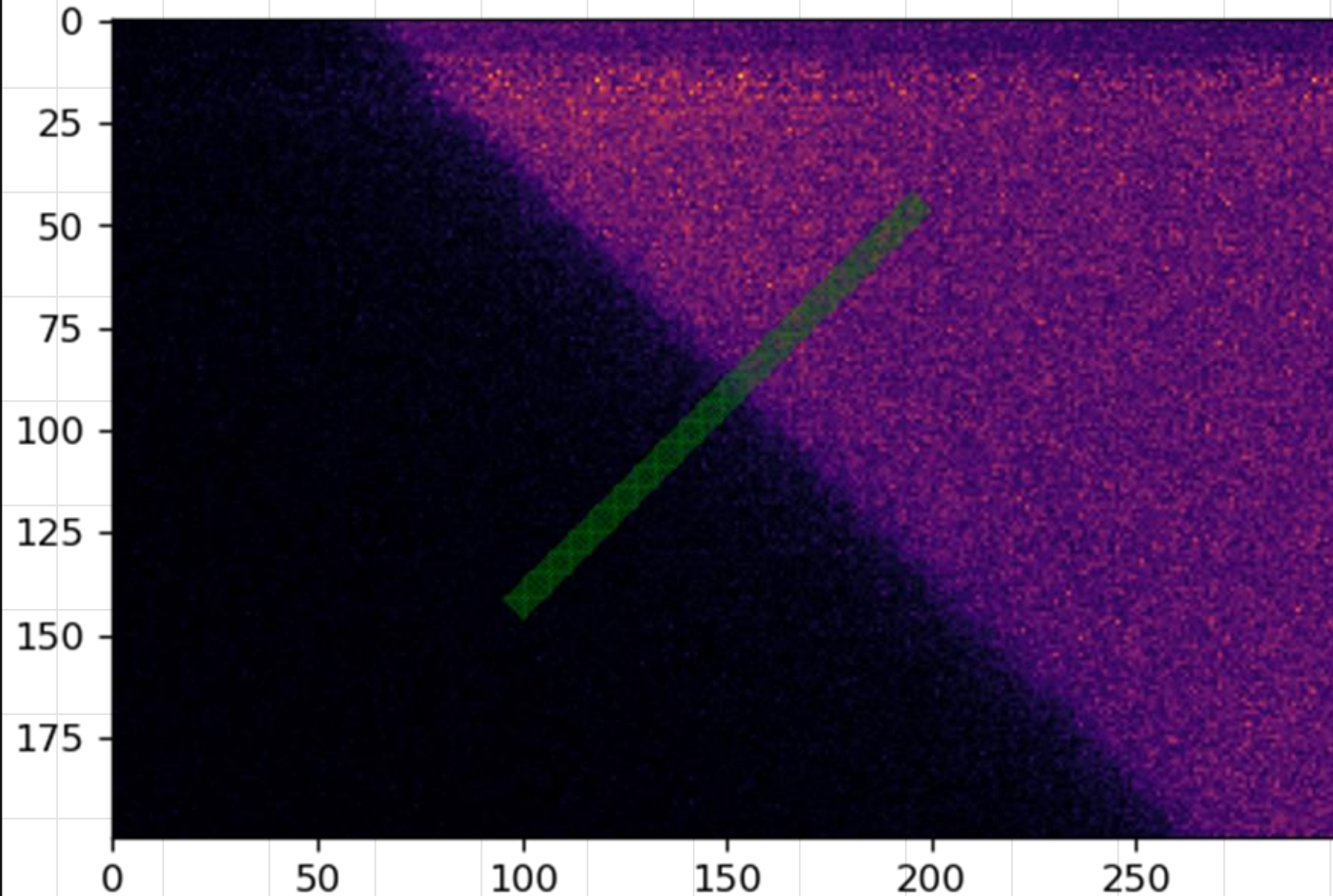


Si tienen preguntas adicionales me pueden  
escribir:

[b.garcia@uniandes.edu.co](mailto:b.garcia@uniandes.edu.co)

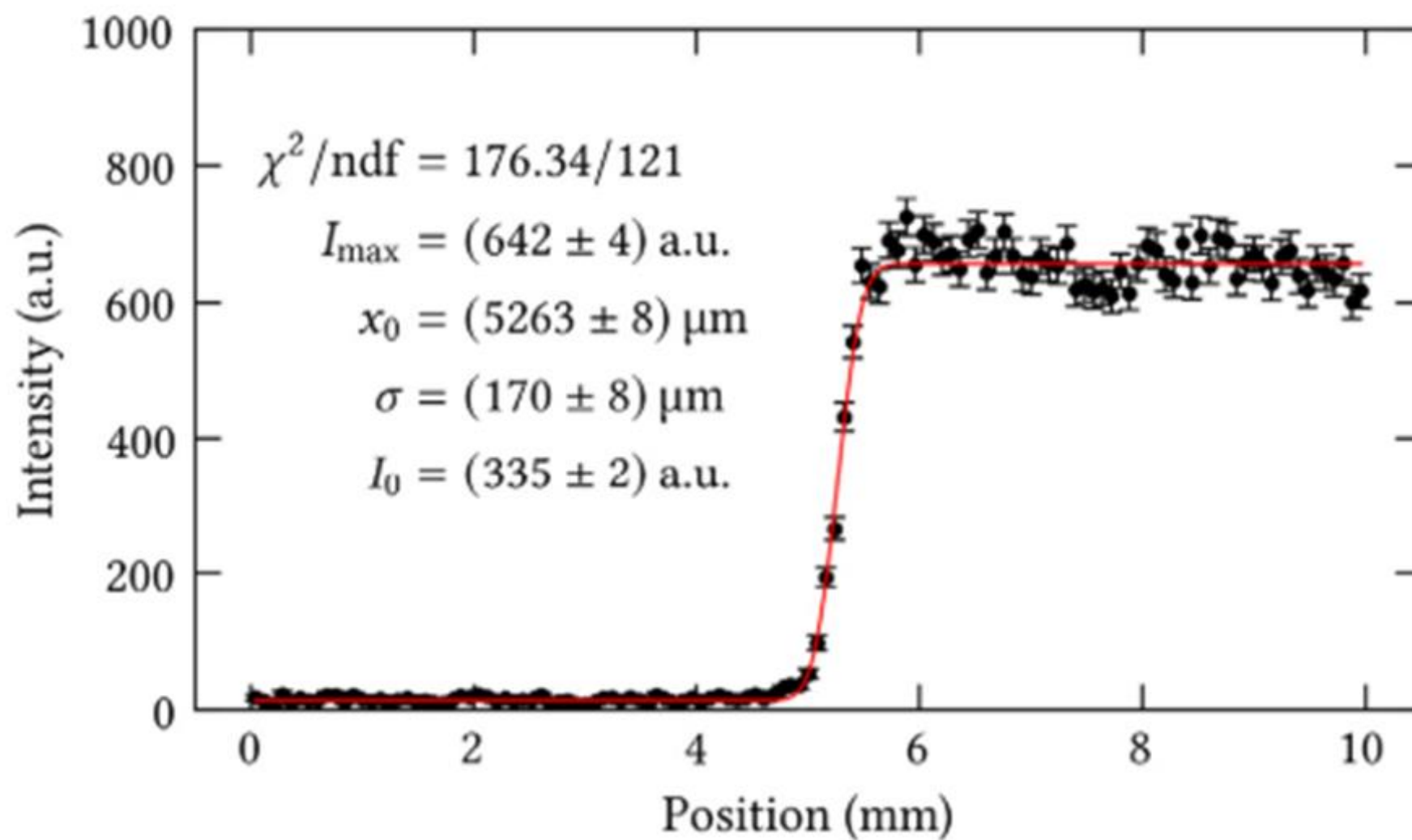
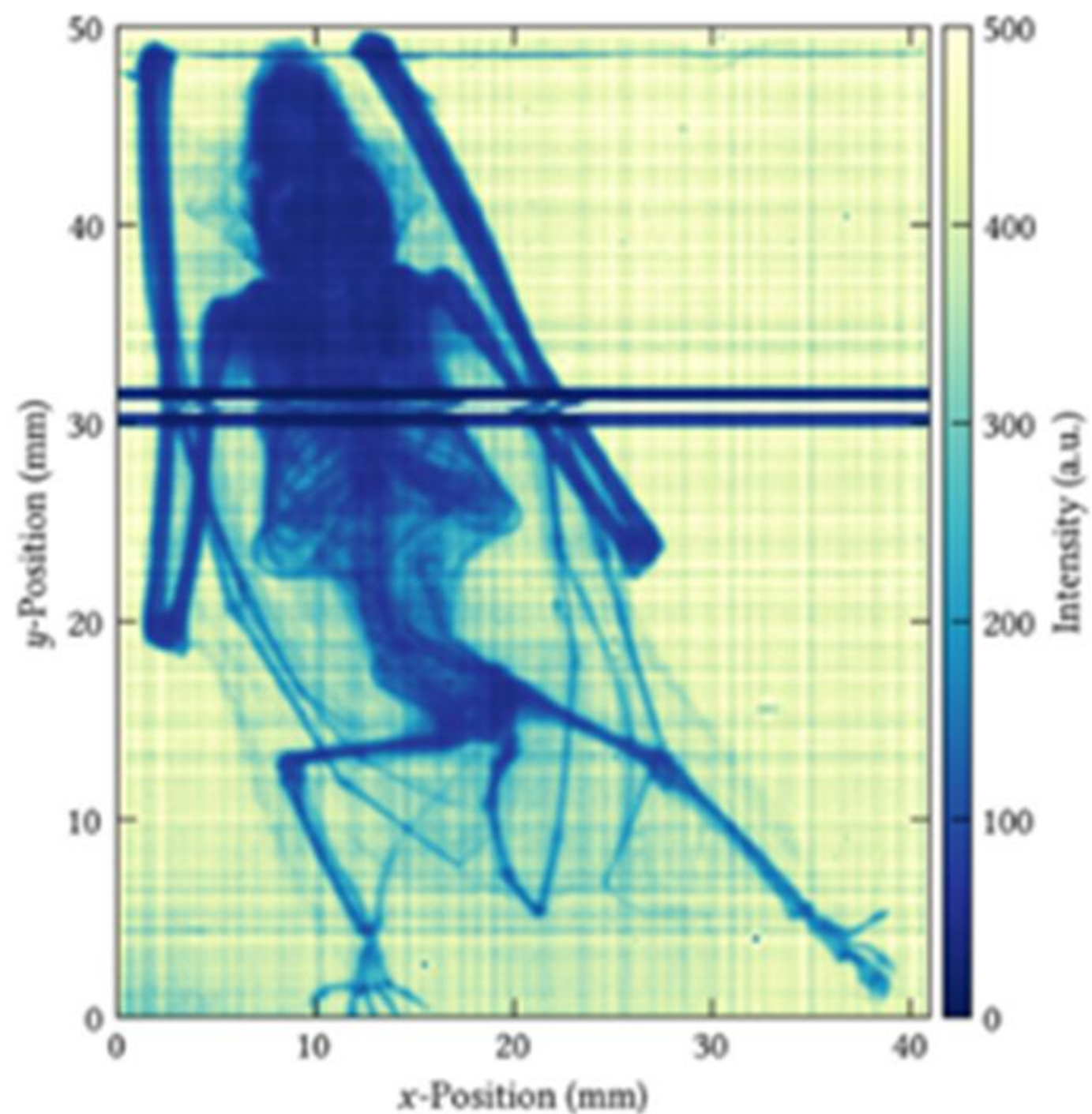
# Resolución Espacial

$$I(x) = I_0 + \frac{I_{max}}{2} \operatorname{erf} \left( \frac{x-x_0}{\sqrt{2}\sigma} \right)$$

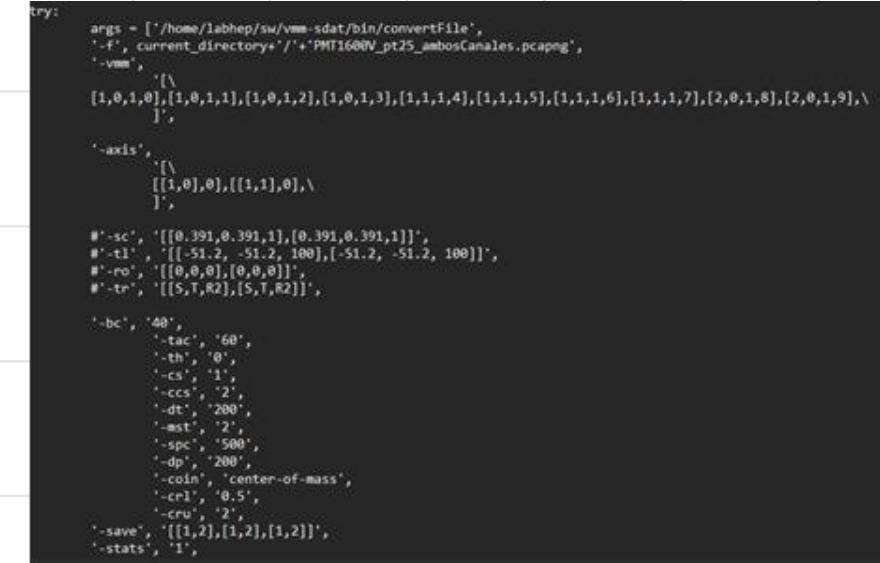
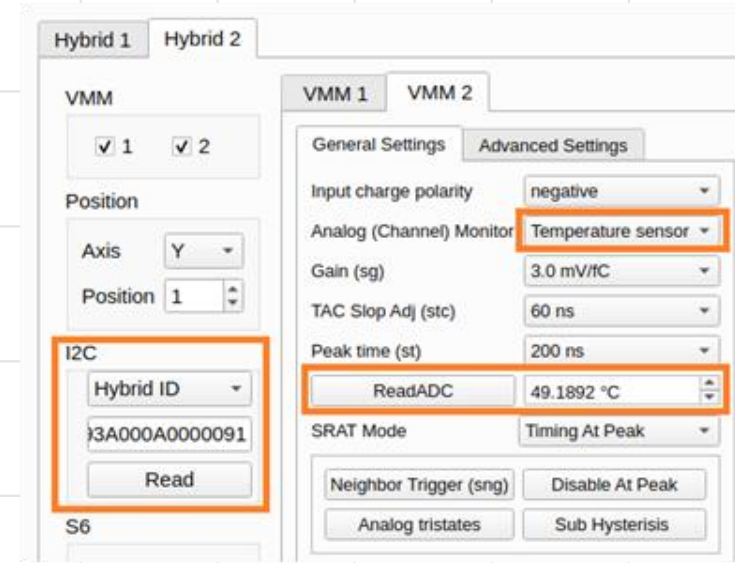
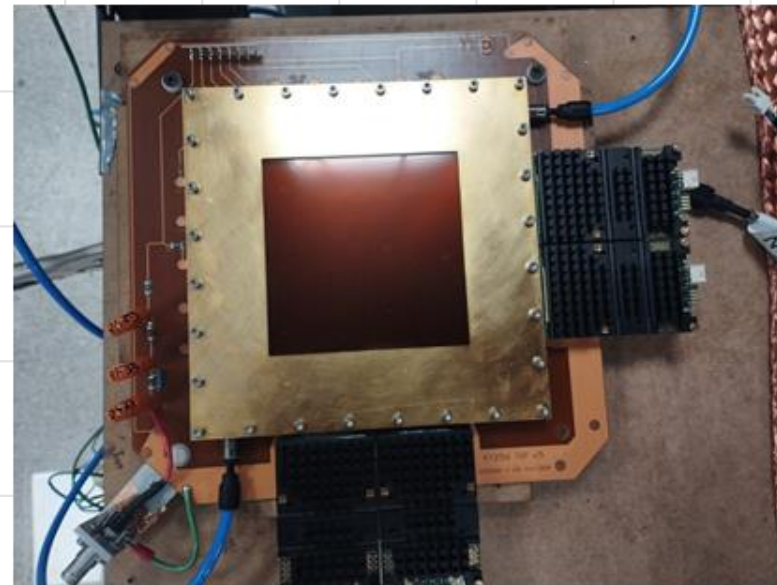
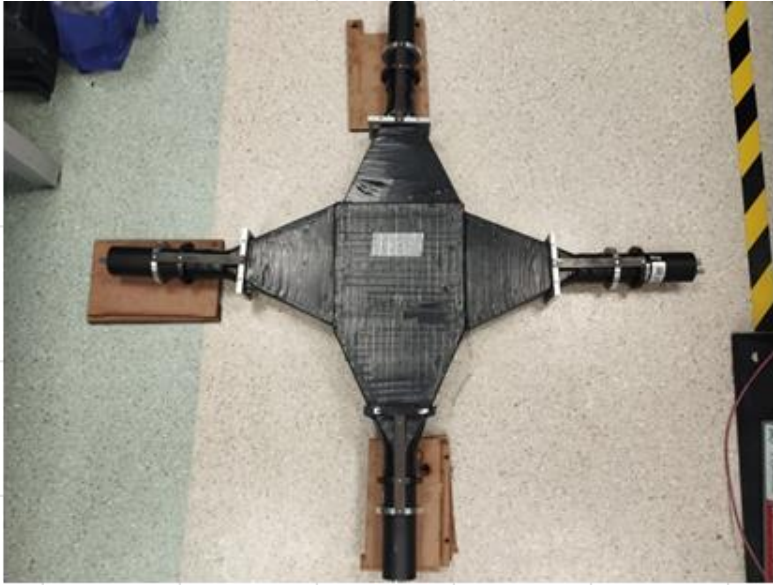


$$\sigma = 340 \pm 50 \mu m$$

# Estado del Arte







Voltaje PMT -2000V

Voltaje -3800V  
a -4200V

Umbral 300 DAC

Default

Umbral 100 mV

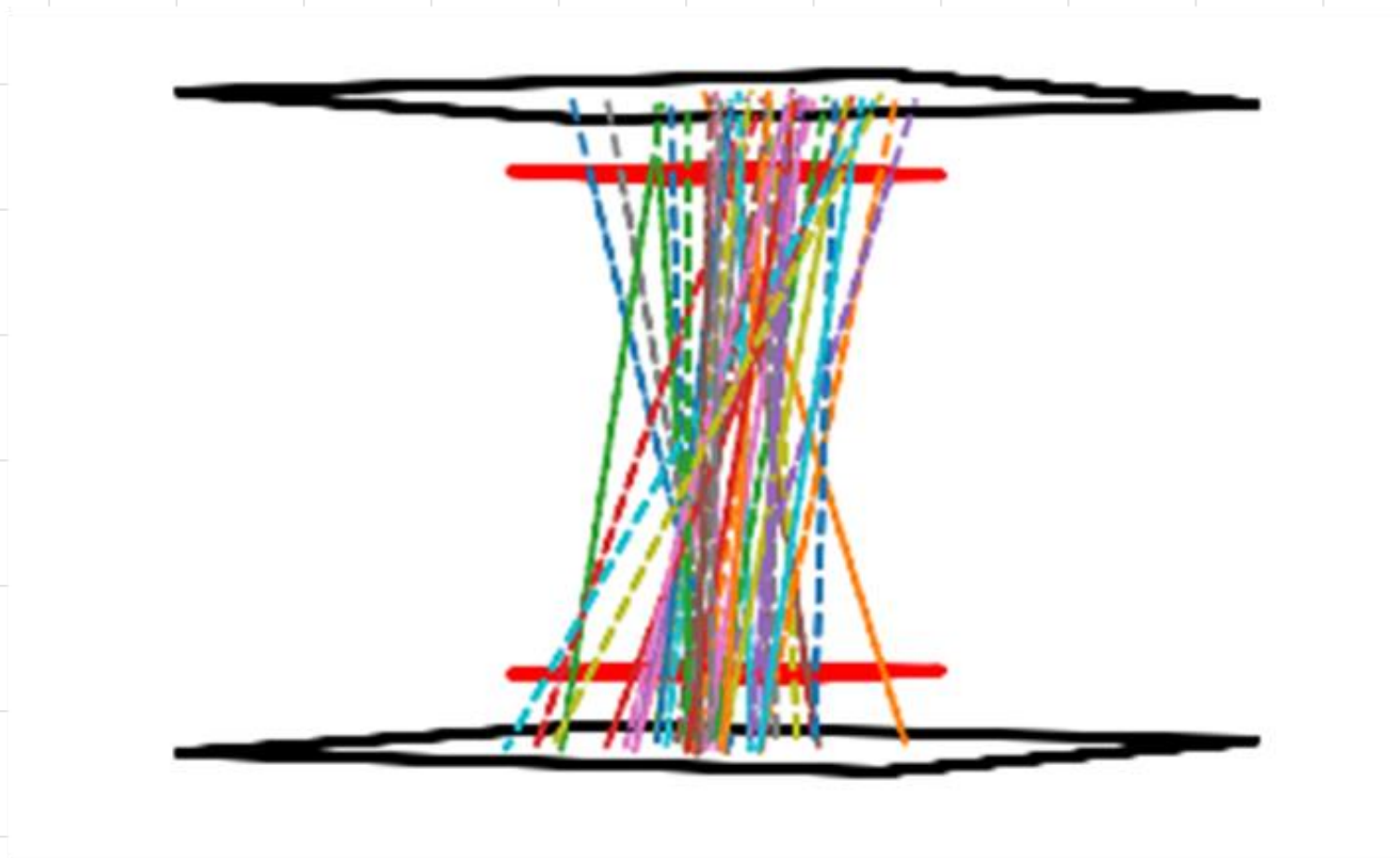
Ganancia 3 mv/fc

Ancho Coincidencia  
25 ns

Peak Time 200 ns

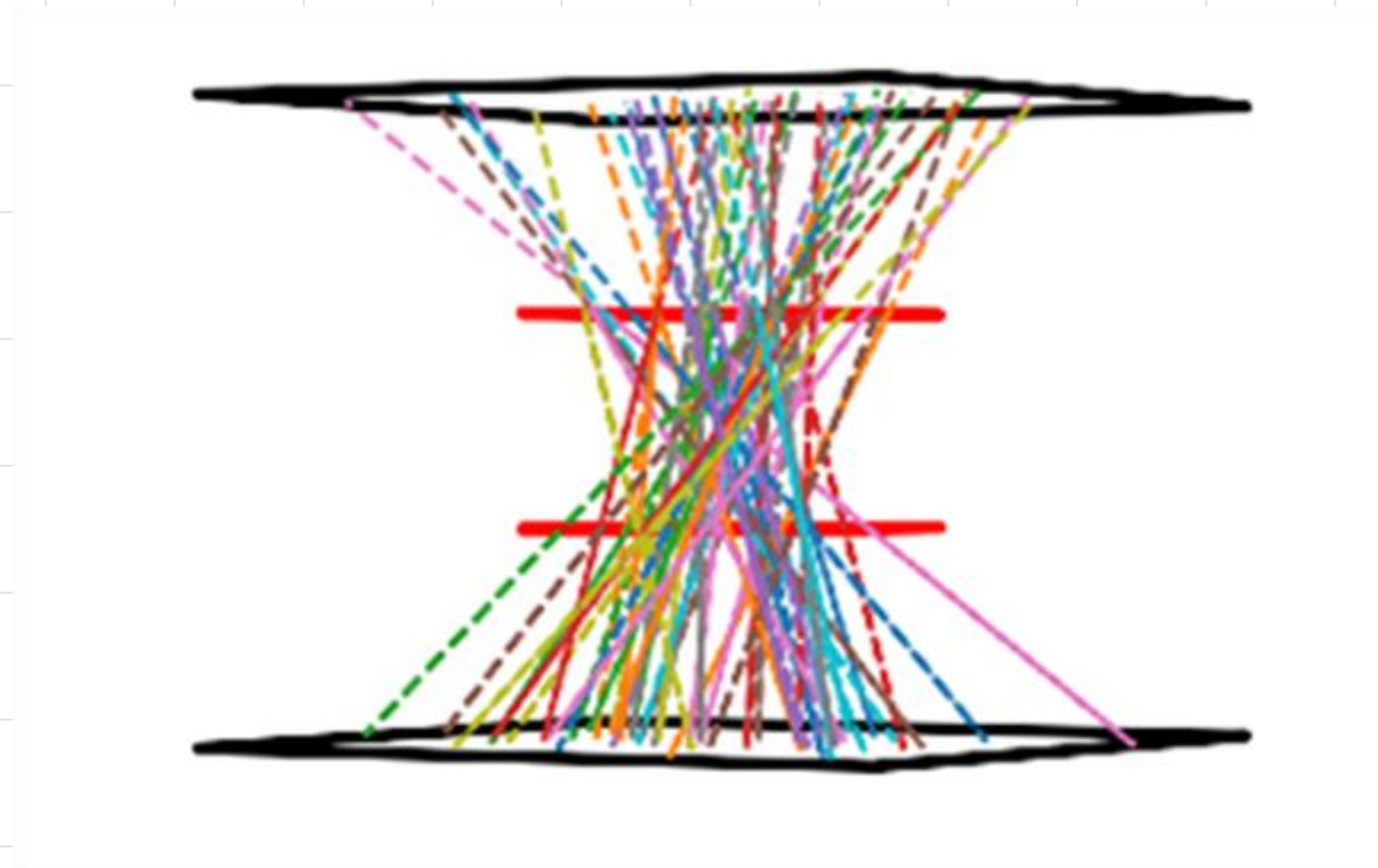
# Muones

GEM separados 1 m



40 Coincidencias Triples

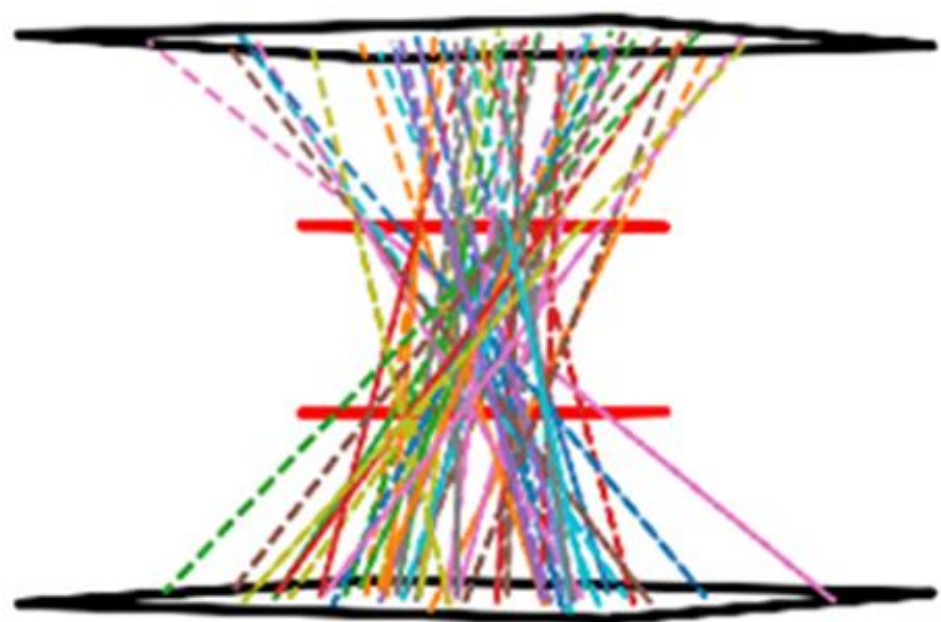
GEM separados 15 cm



449 Coincidencias Triples

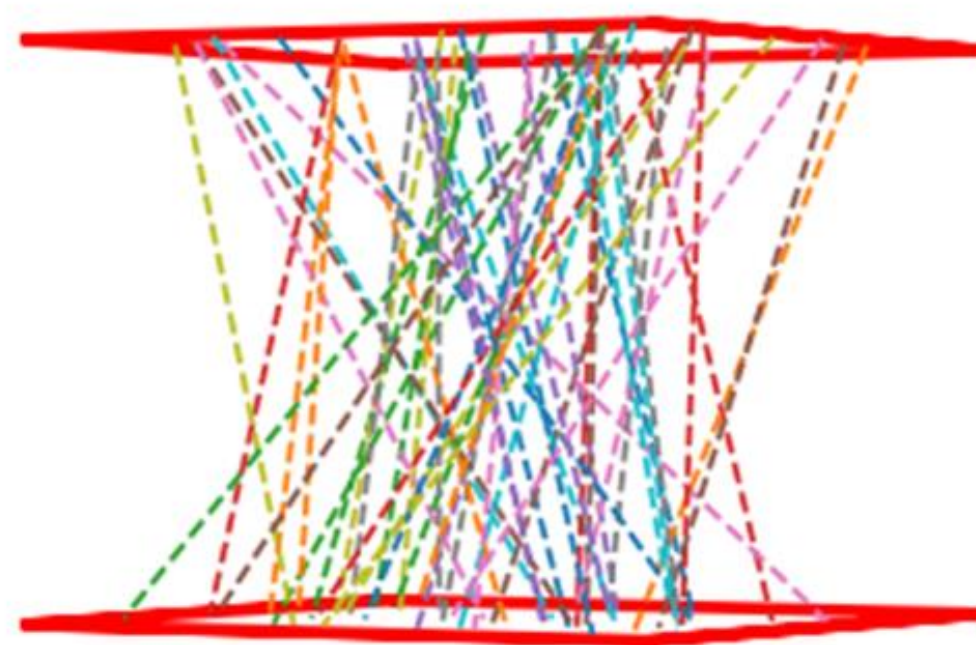
# Muones

Coincidencia Triple



449 Coincidencias Triples

Coincidencia Doble



508 Coincidencias Triples