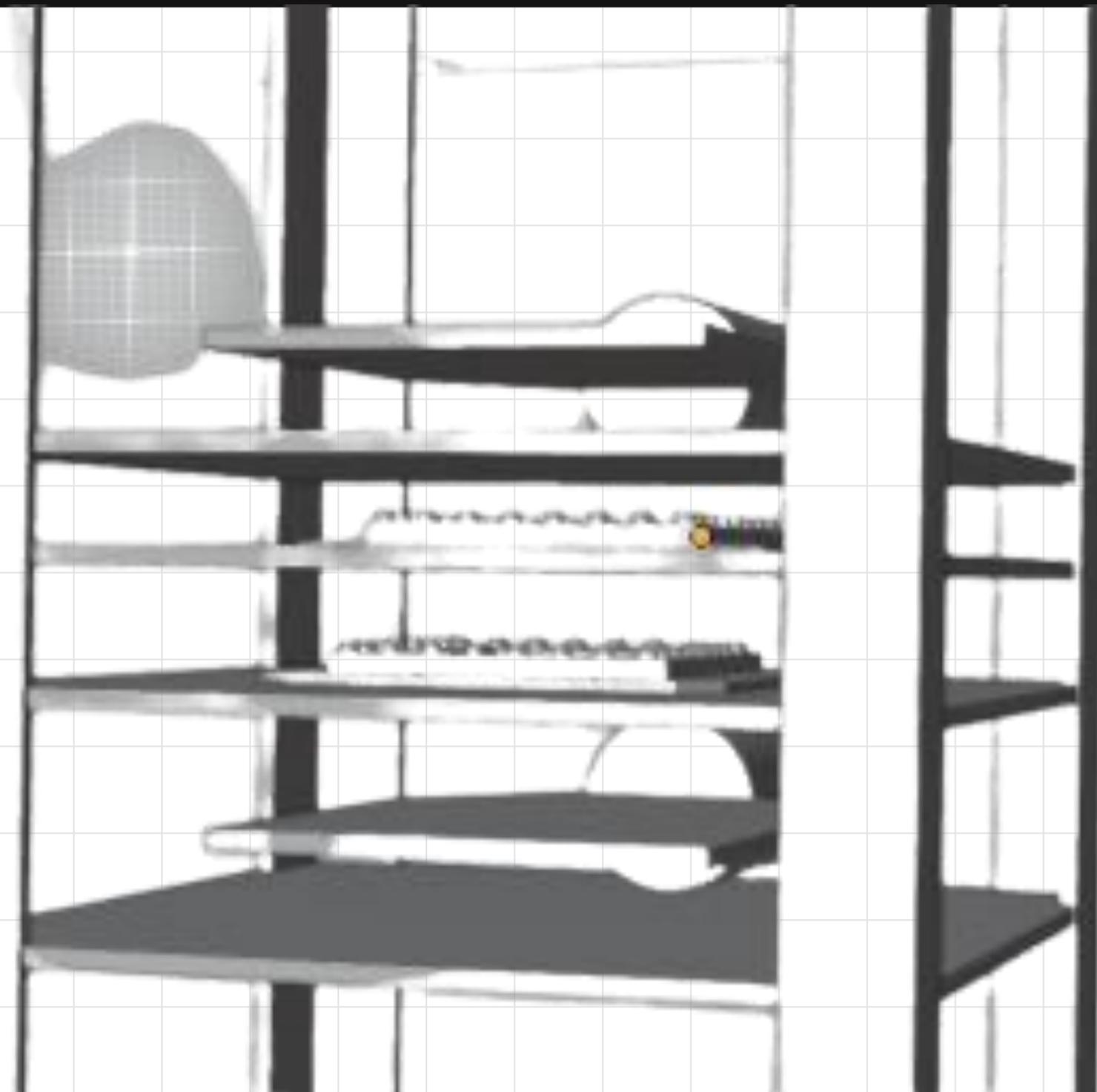


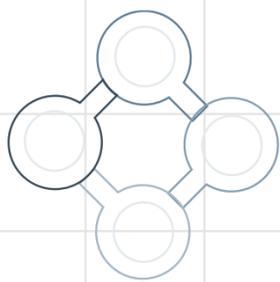
# Hodoscopio GEM con lectura SRS

Autor: Brayan Garcia

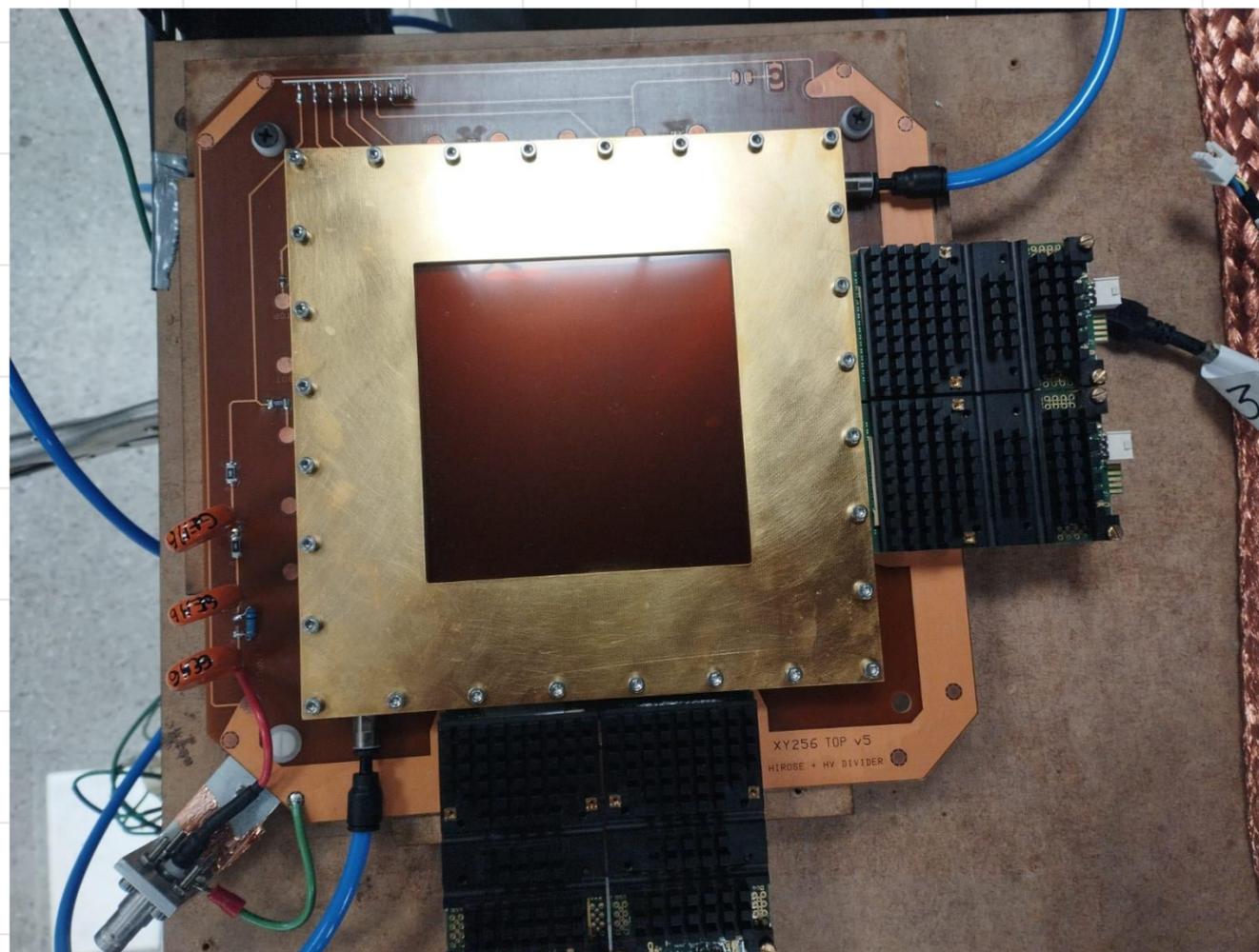
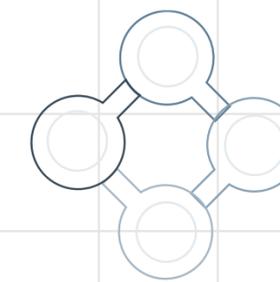
Coautor: Carlos Avila



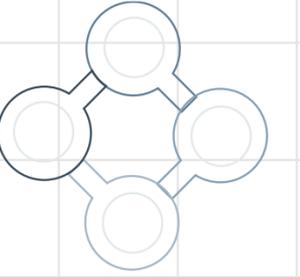
Universidad de los Andes | Grupo de Investigación  
Altas Energías



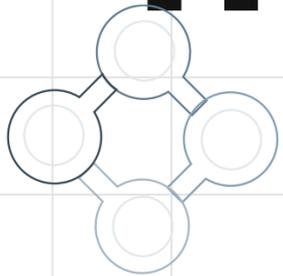
# Detector GEM



- *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?

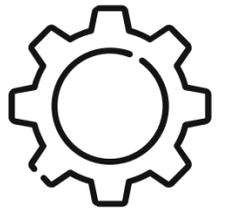
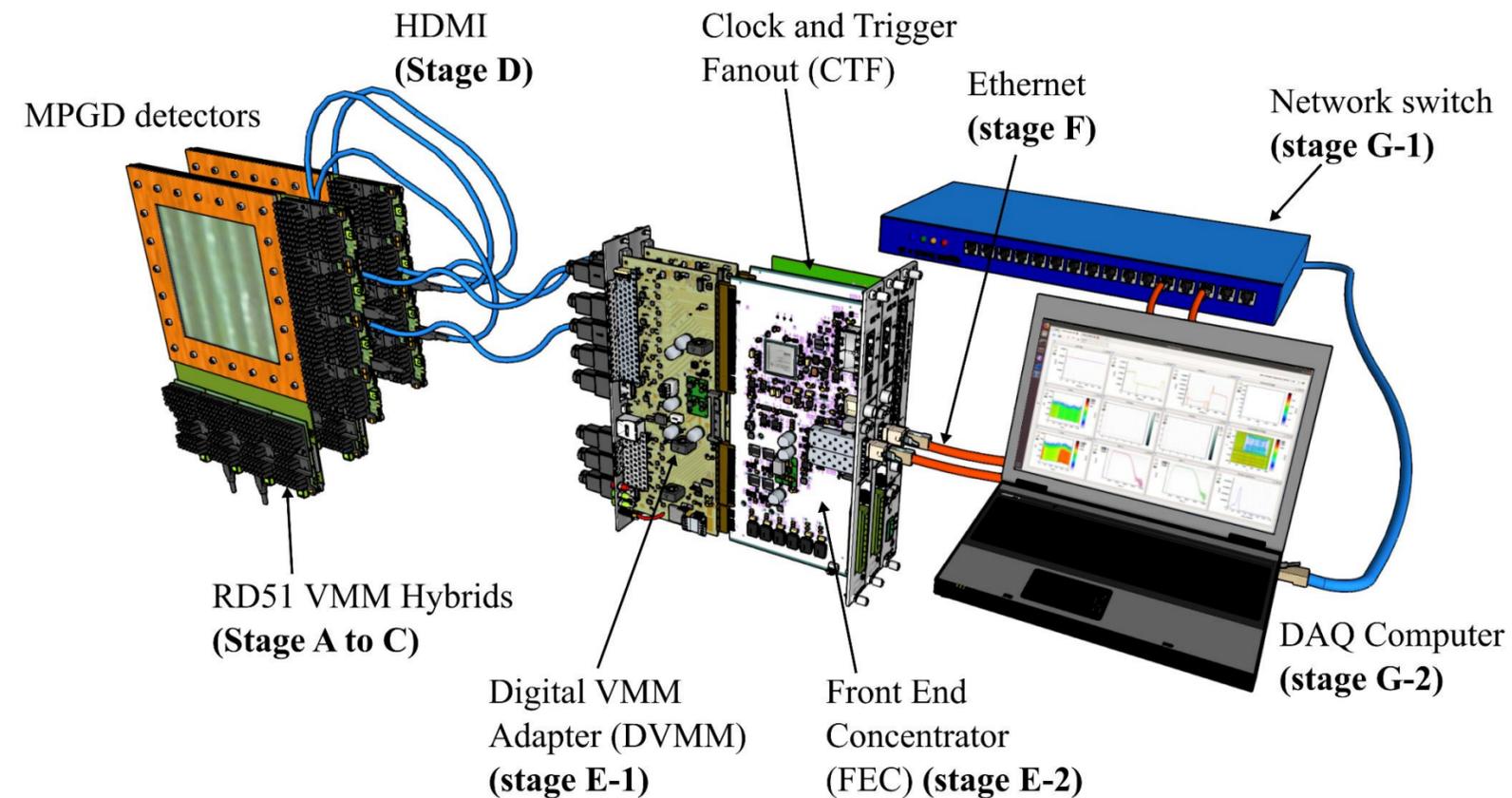


# Sistema de Adquisición SRS

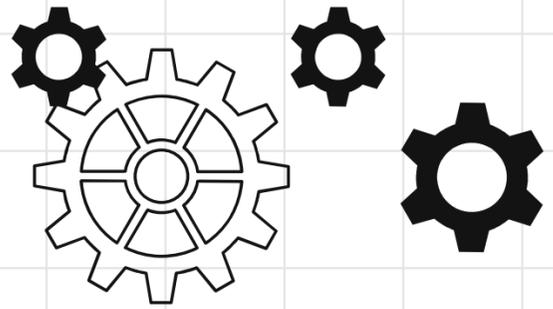


## Sistema Escalable de Lectura (SRS)

### Desarrollado por el laboratorio RD51

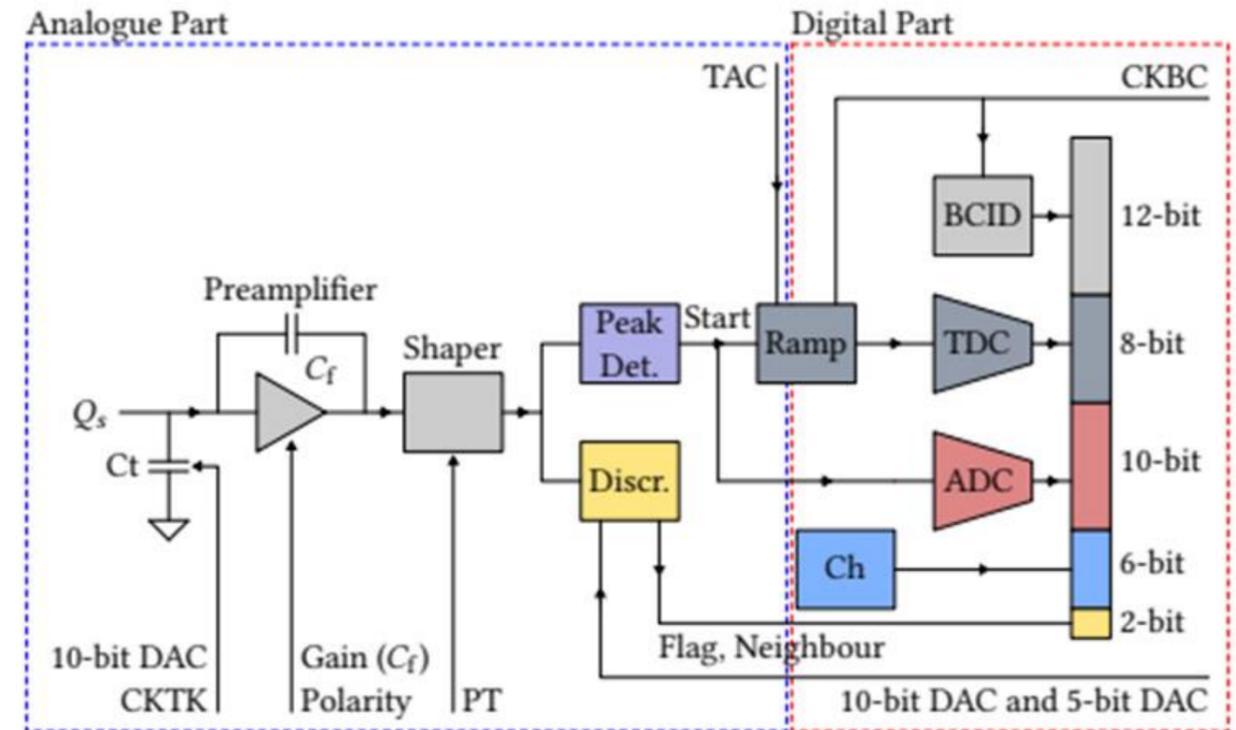
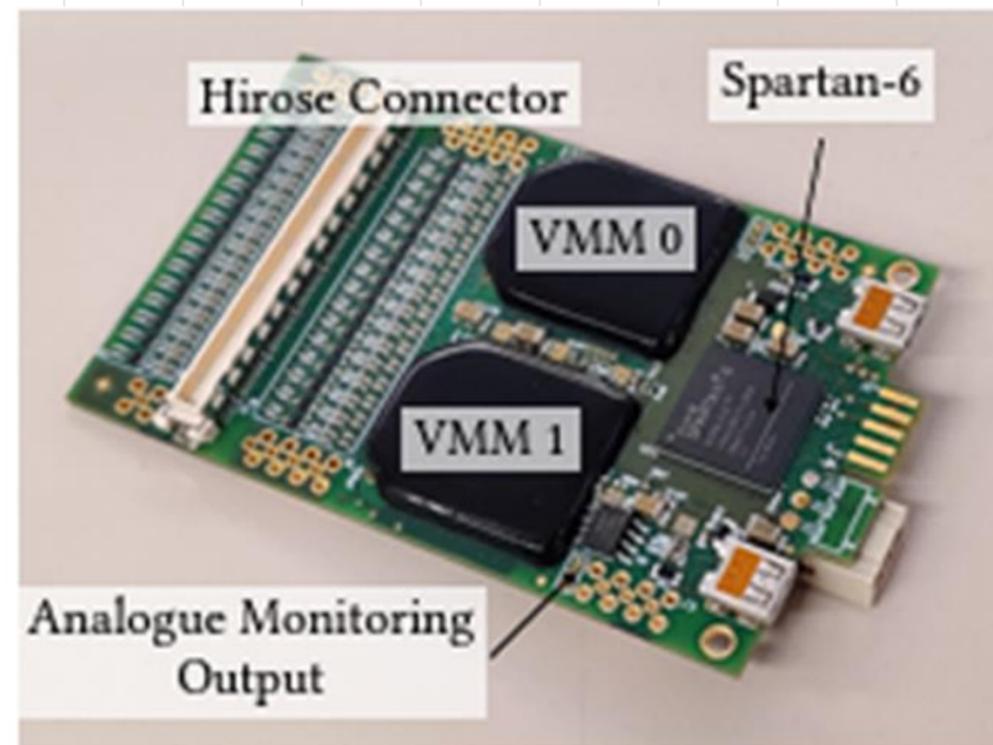


Tomado de :  
Rate-capability of the VMM3a front-end in the RD51 Scalable Readout System



# Chip Vmm

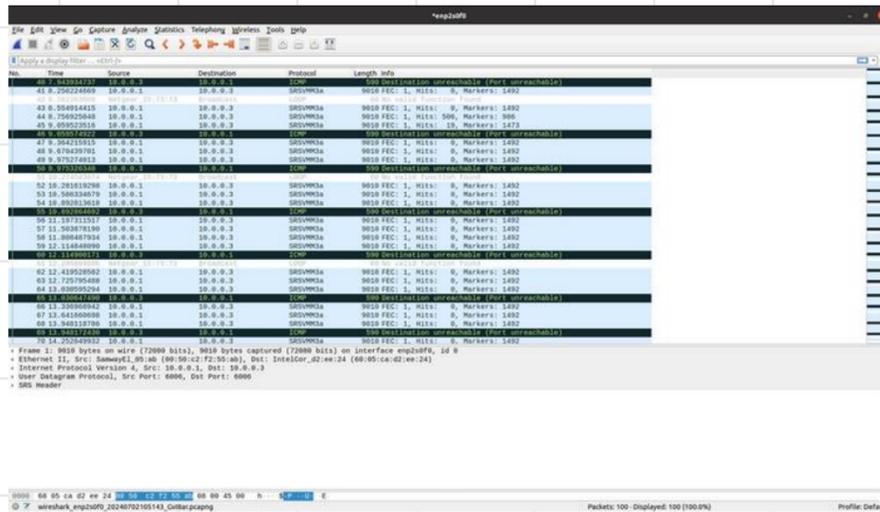
Chip de 64 Canales  
Desarrollado en el Laboratorio  
Brookhaven



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	0 mV	0 mV	0 ns	0 mV
SL	0 mV	0 mV	0 ns	0 mV
ST	0 mV	0 mV	0 ns	0 mV
STH	0 mV	0 mV	0 ns	0 mV
SM	0 mV	0 mV	0 ns	0 mV
SMX	0 mV	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

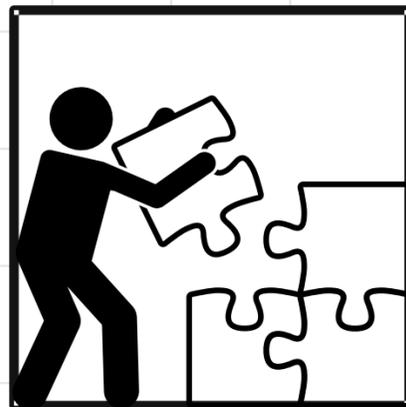
Umbral **300 DAC**  
Ganancia **3 mv/fc**  
Peak Time **200 ns**

Pulso de Prueba  
Enmascarar Canales  
Lógica Vecinos

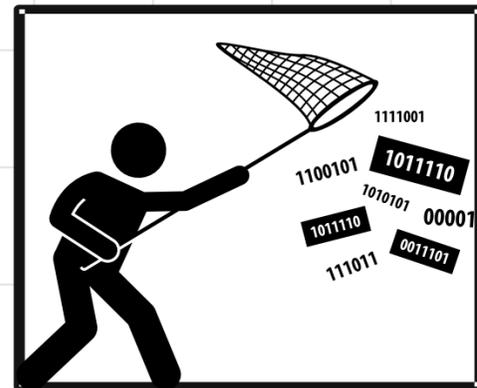
# Metodología



*Comprobar el funcionamiento.*



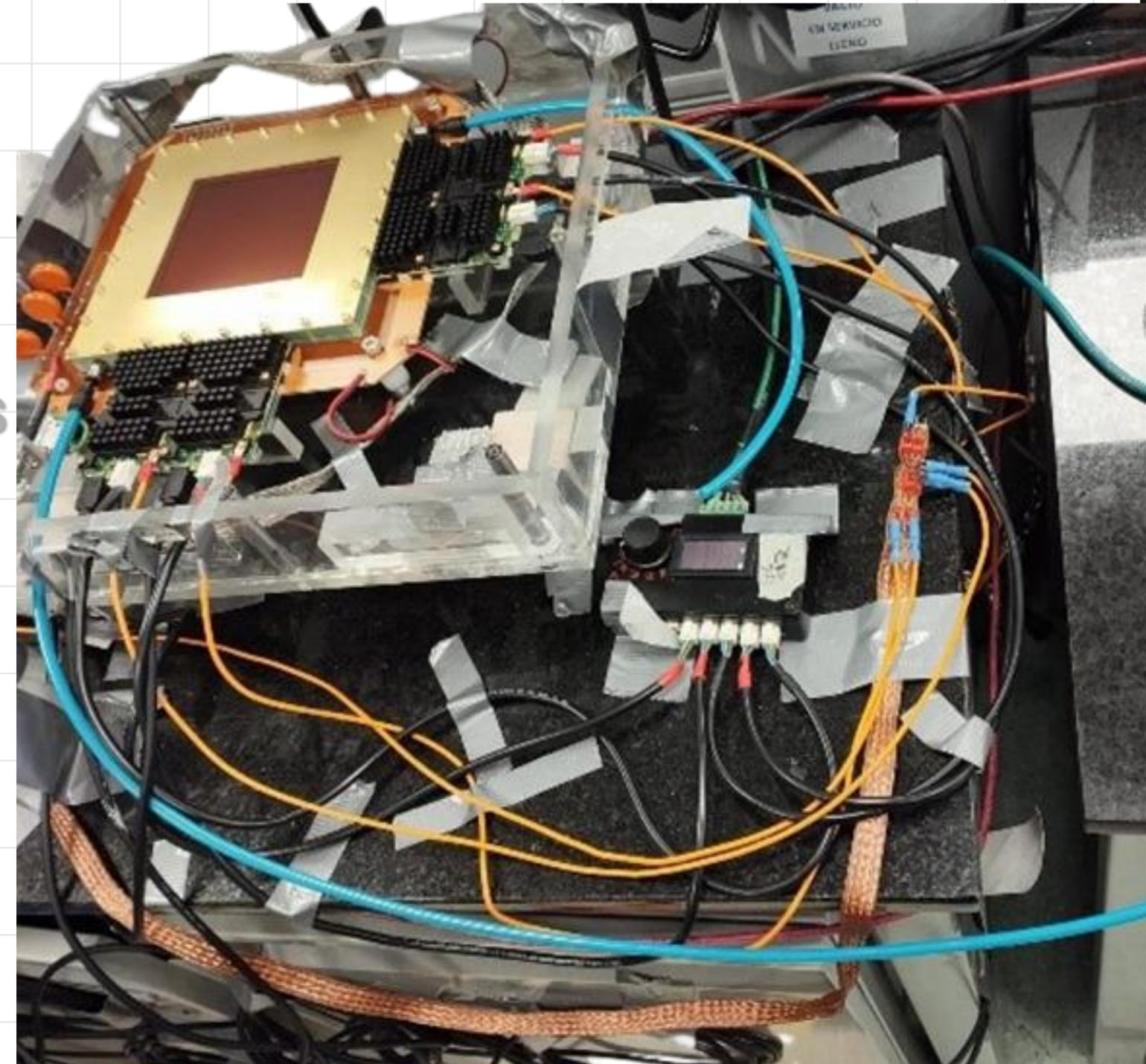
*Realizar el Montaje de los detectores GEM.*



*Tomar datos con el Hodoscopio.*

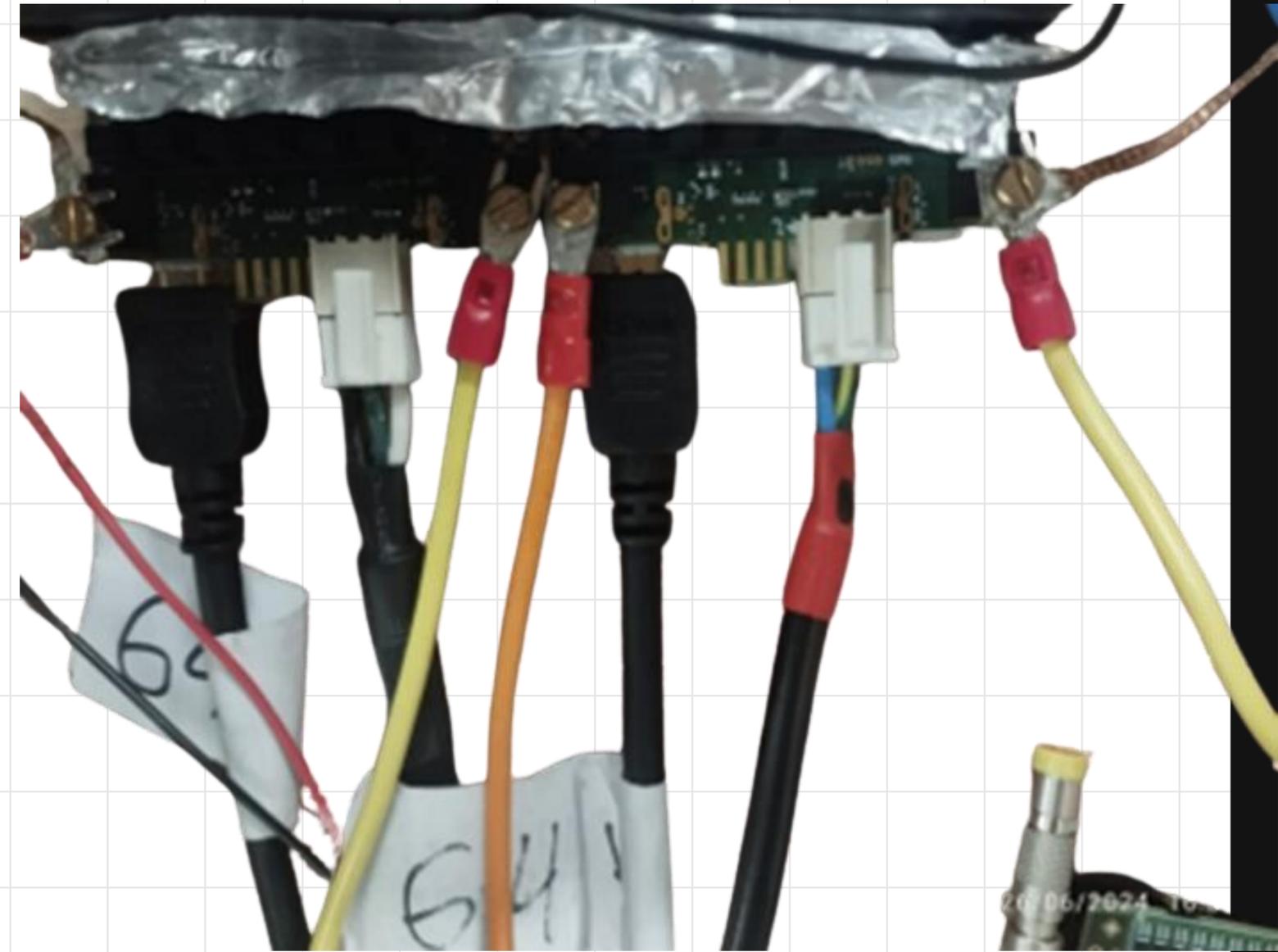
# Preparar el GEM

- **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



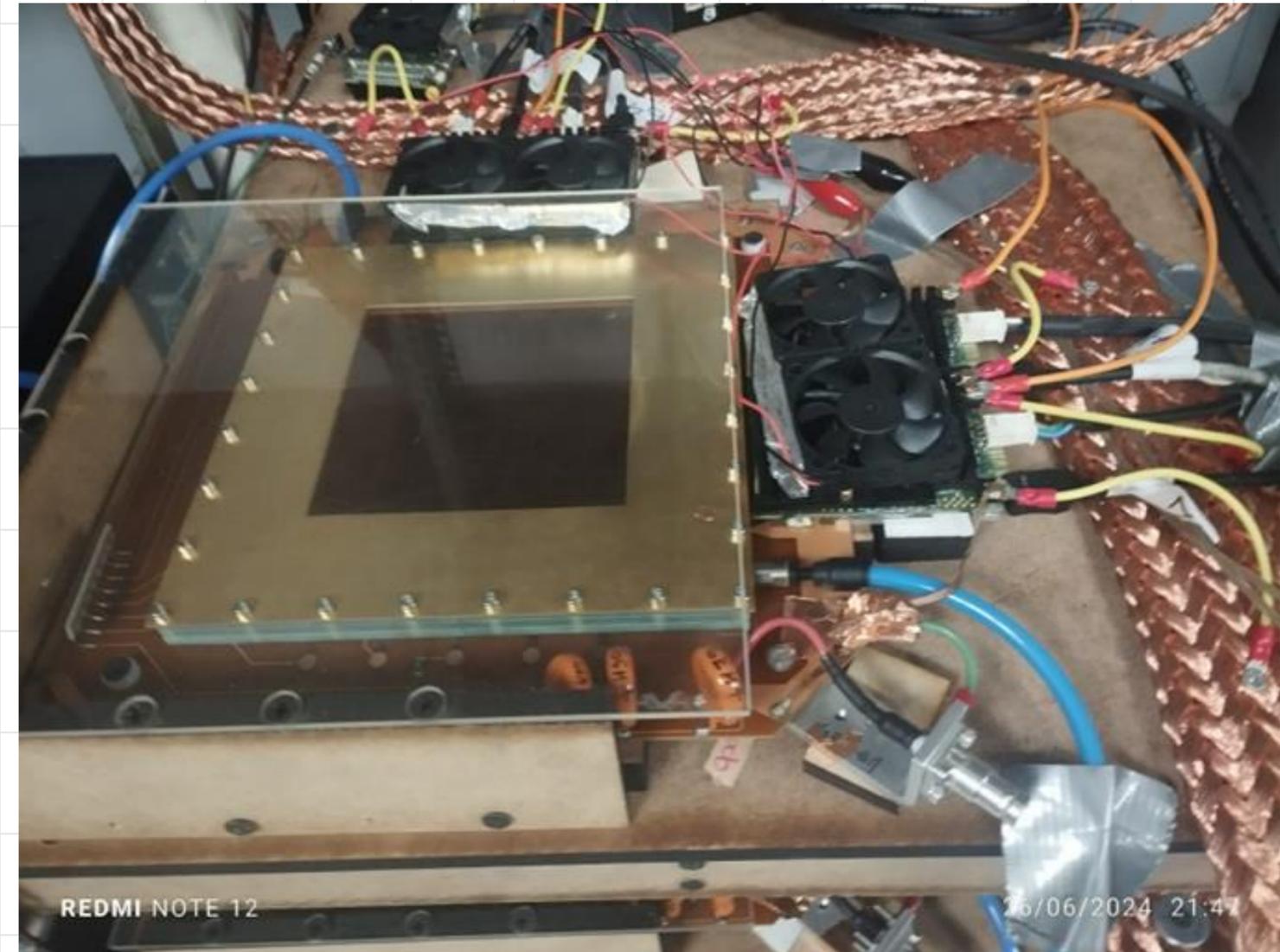
# Preparar el GEM

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Tierra de Cobre  
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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

Hybrid 1 Hybrid 2

VMM

1  2

Position

Axis Y

Position 1

I2C

Hybrid ID

93A000A0000091

Read

S6

VMM 1 VMM 2

General Settings Advanced Settings

Input charge polarity negative

Analog (Channel) Monitor Temperature sensor

Gain (sg) 3.0 mV/fC

TAC Slop Adj (stc) 60 ns

Peak time (st) 200 ns

ReadADC 49.1892 °C

SRAT Mode Timing At Peak

Neighbor Trigger (sng) Disable At Peak

Analog tristates 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

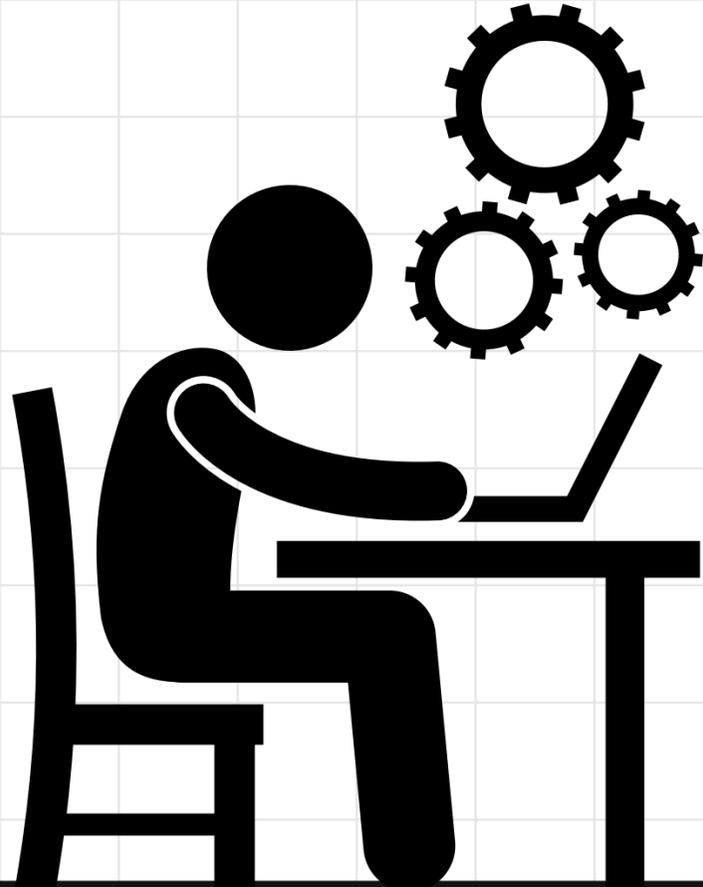


# Operación

- **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?



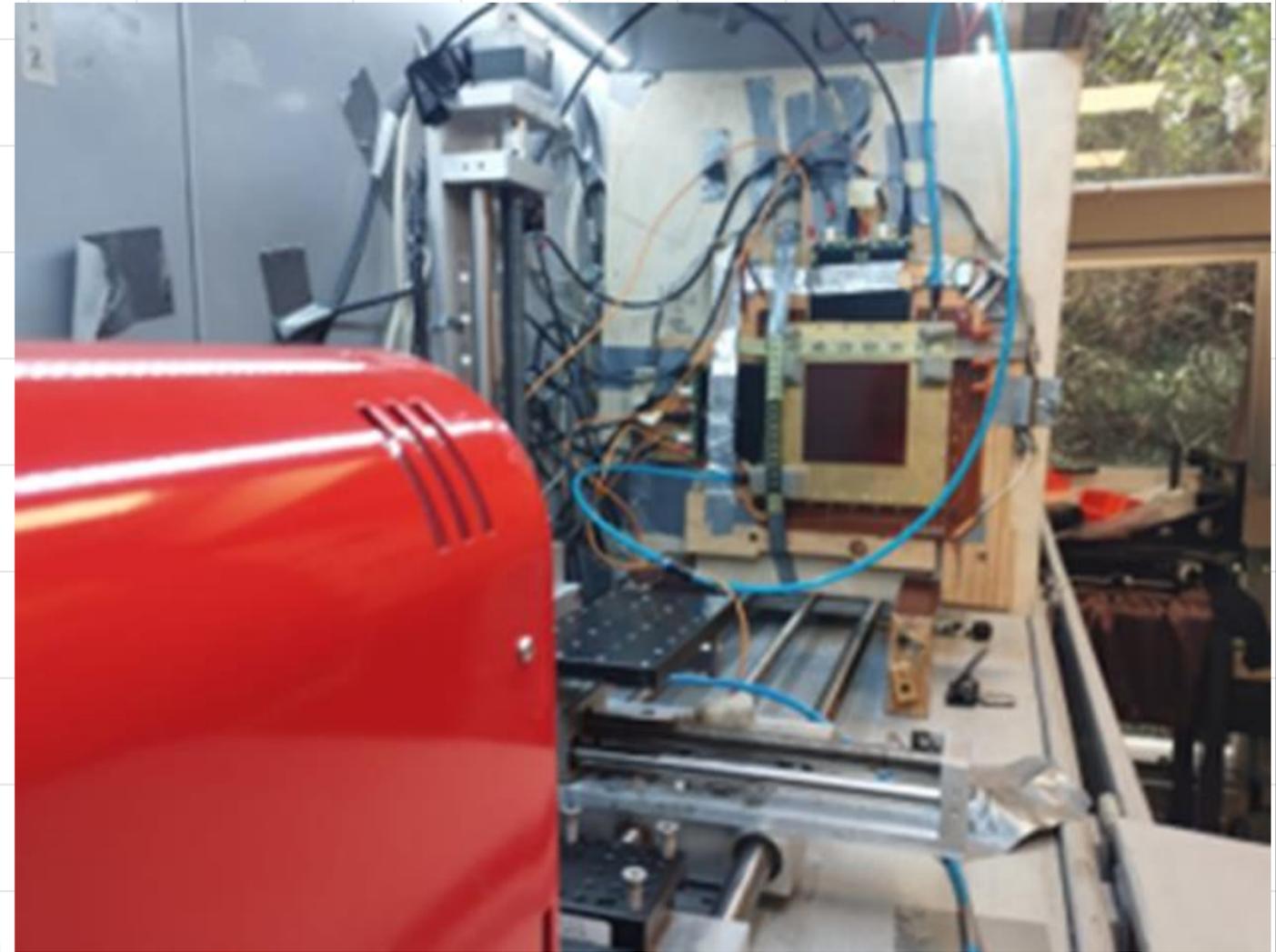
# Rayos X

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

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

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

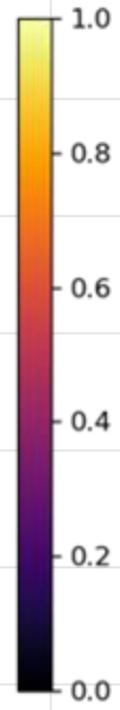
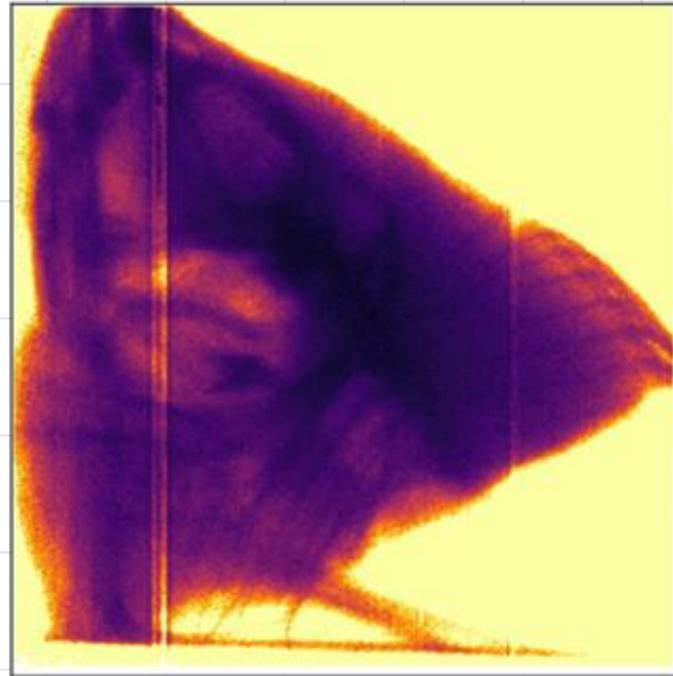
**Se realizó las correcciones de Campo Plano**



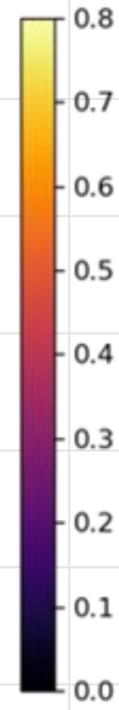
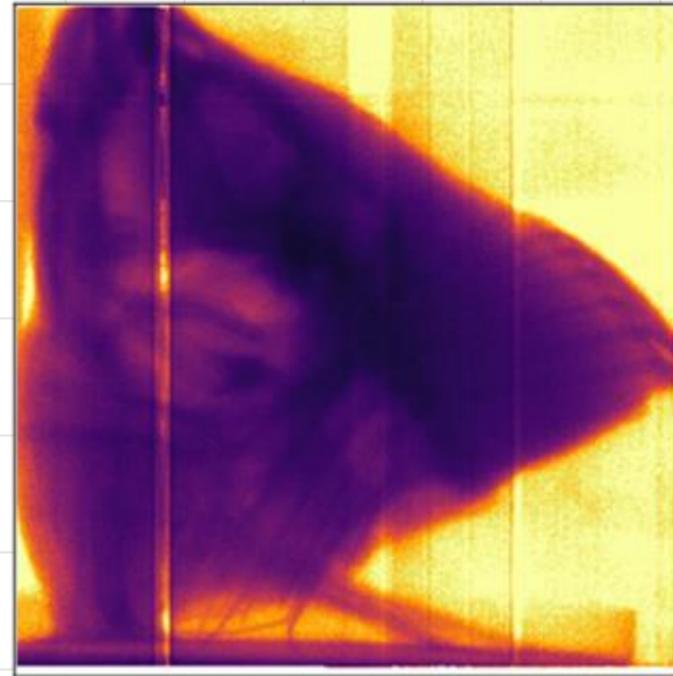
86 cm



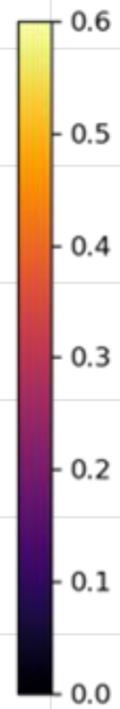
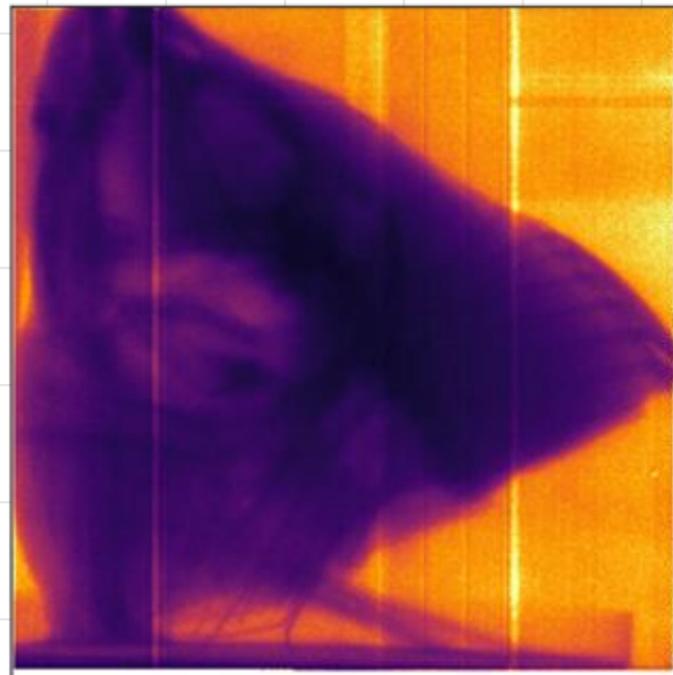
Voltaje 21 kV



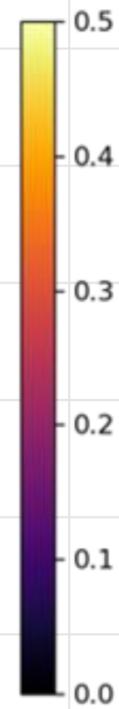
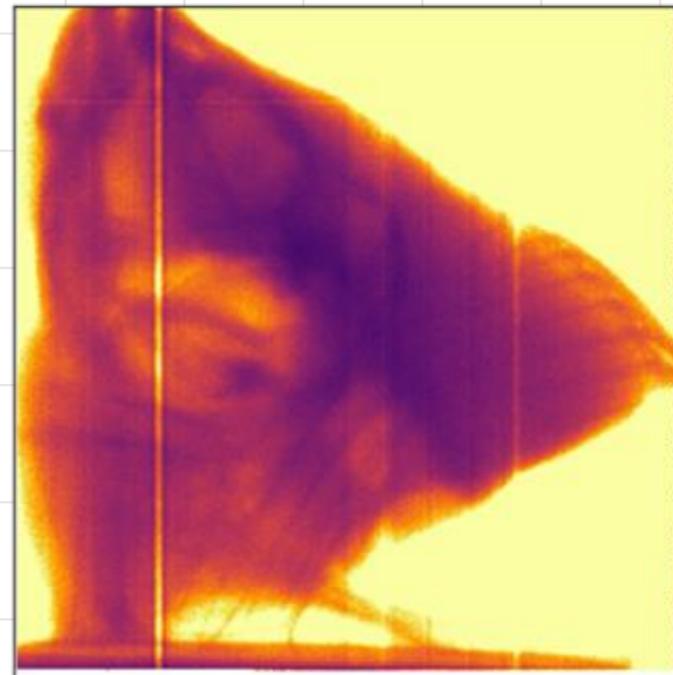
Voltaje 30 kV

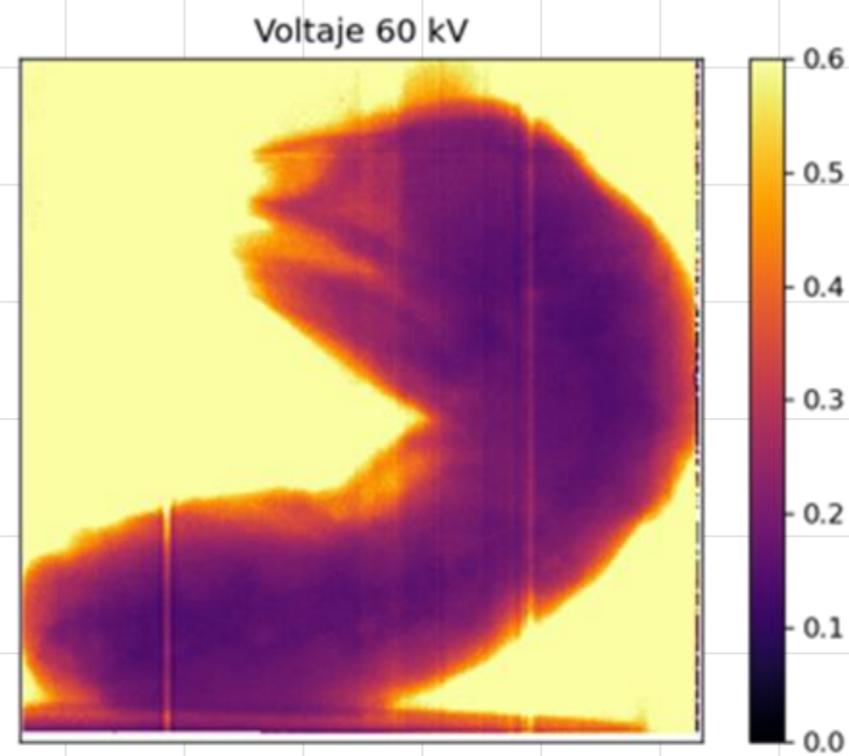
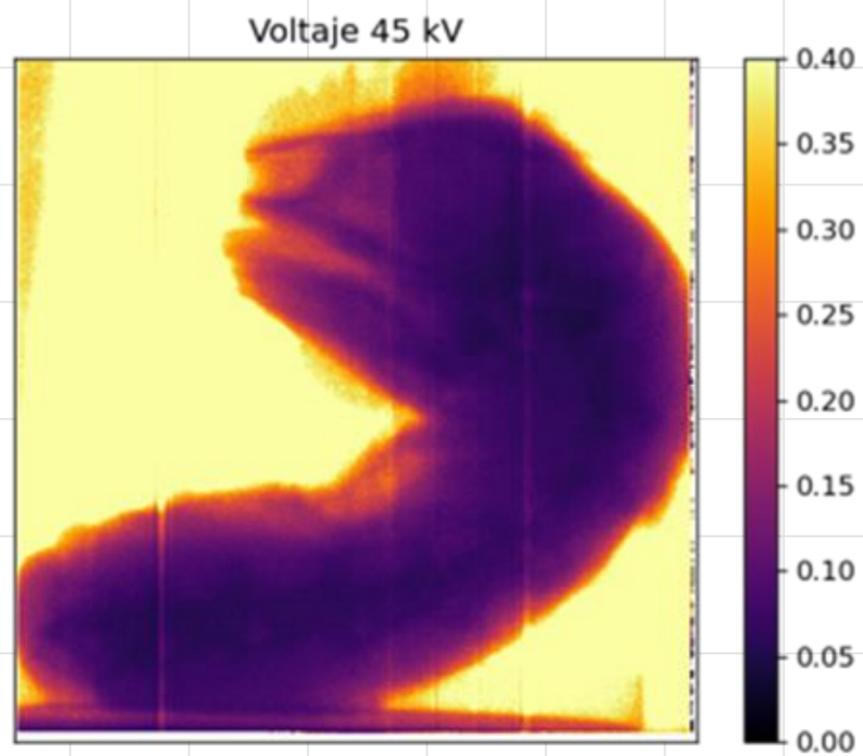
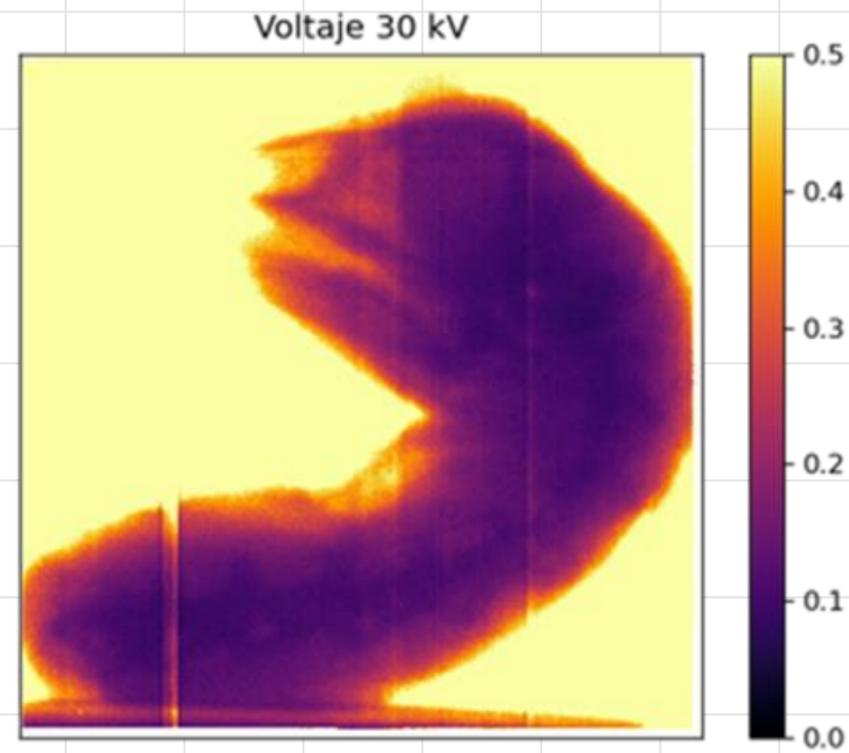
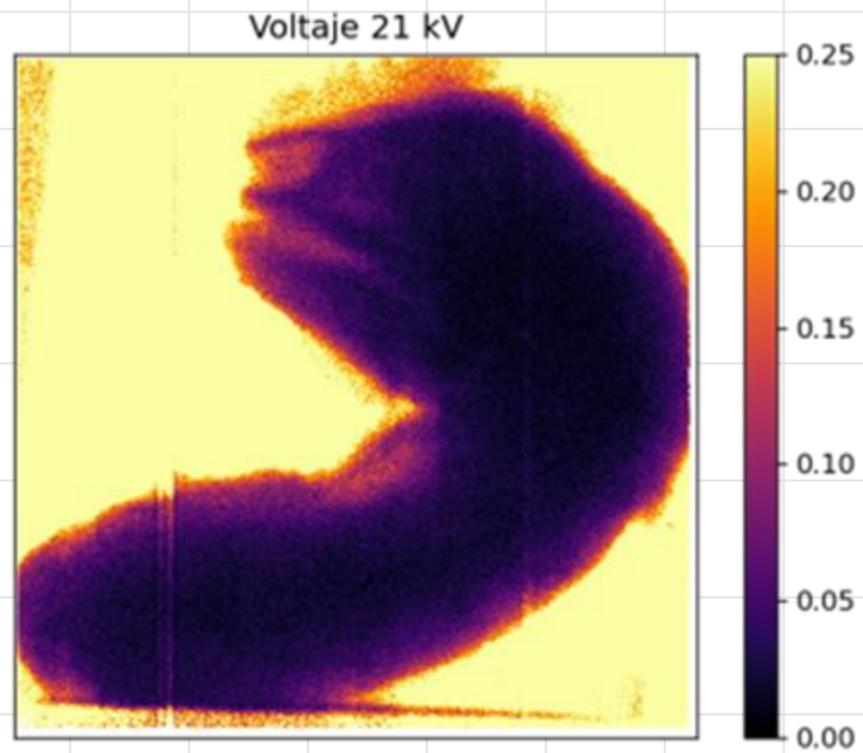


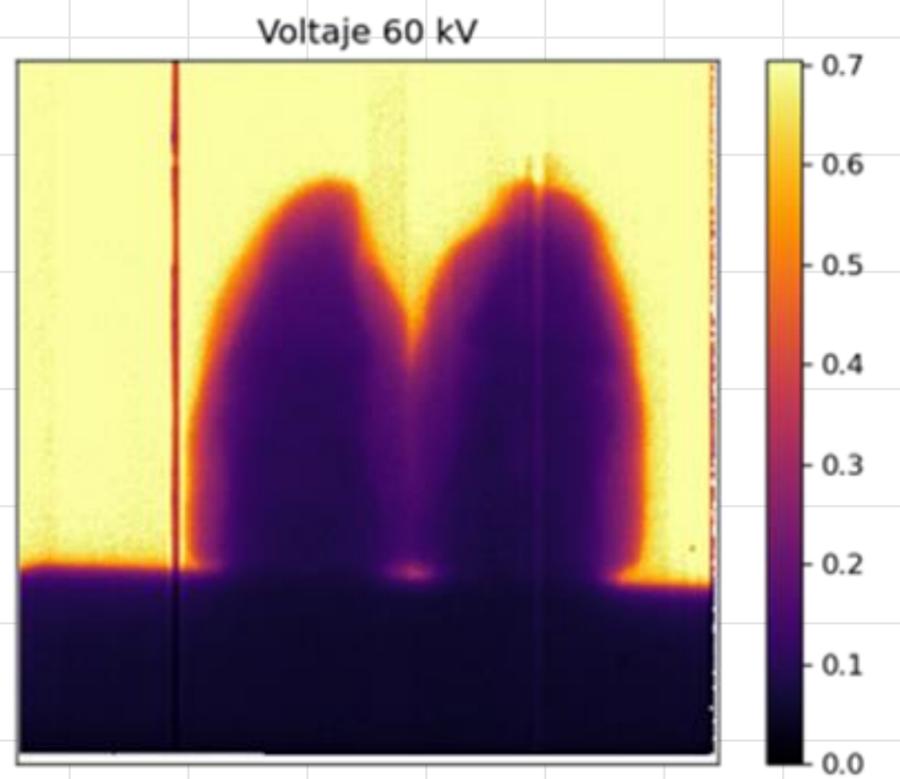
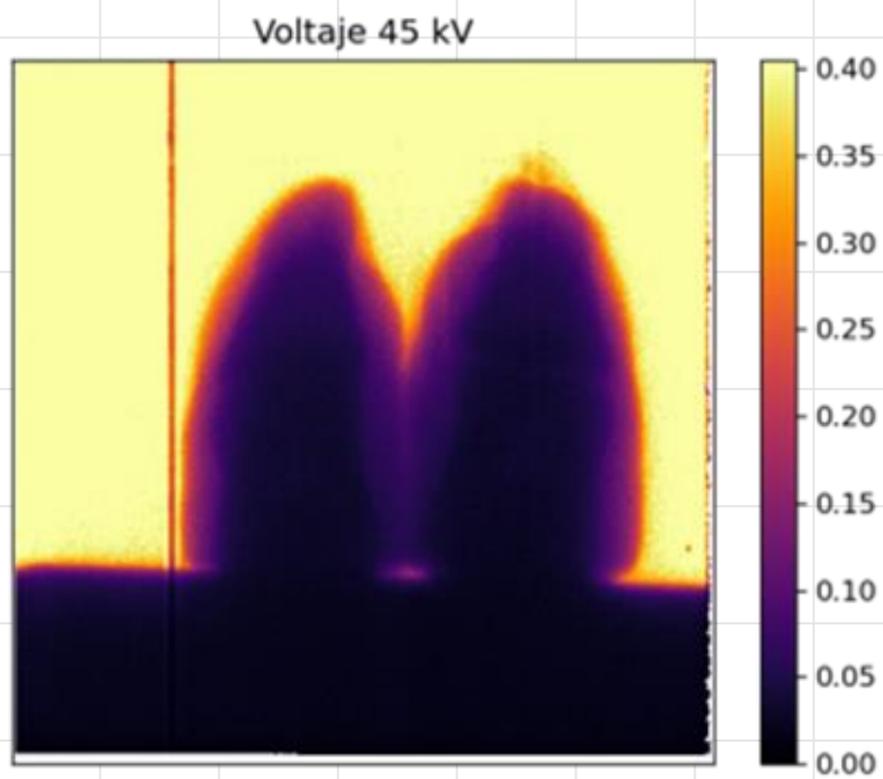
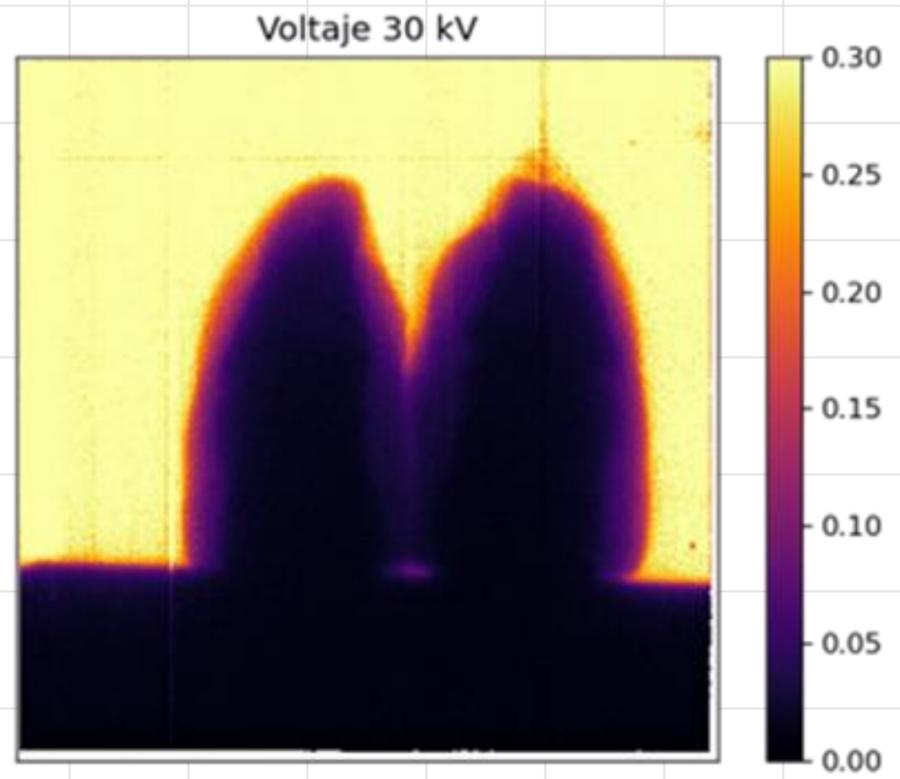
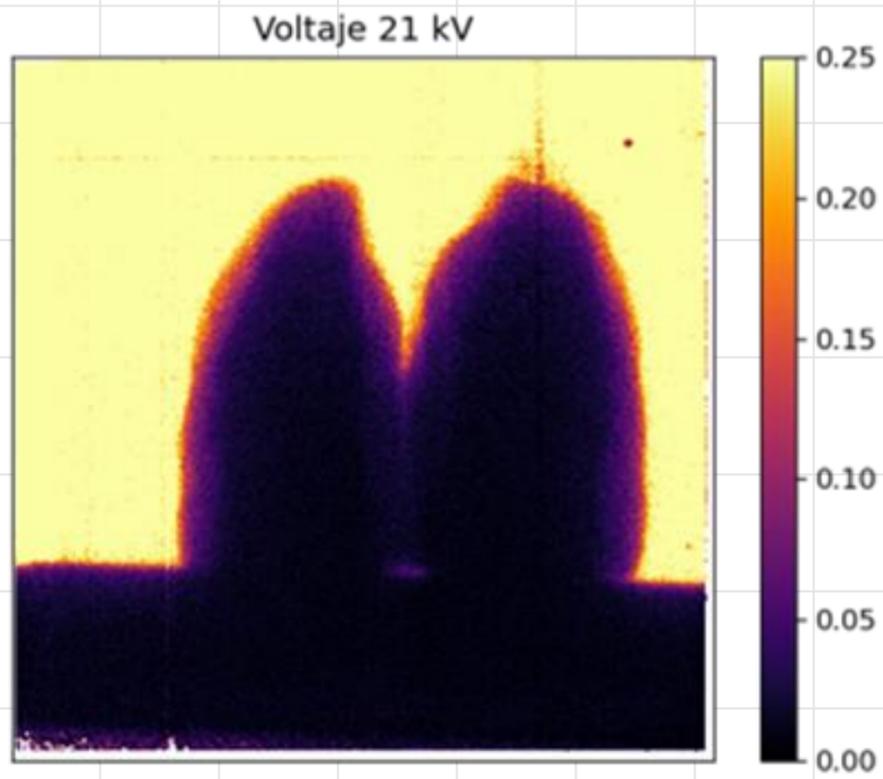
Voltaje 45 kV



Voltaje 60 kV

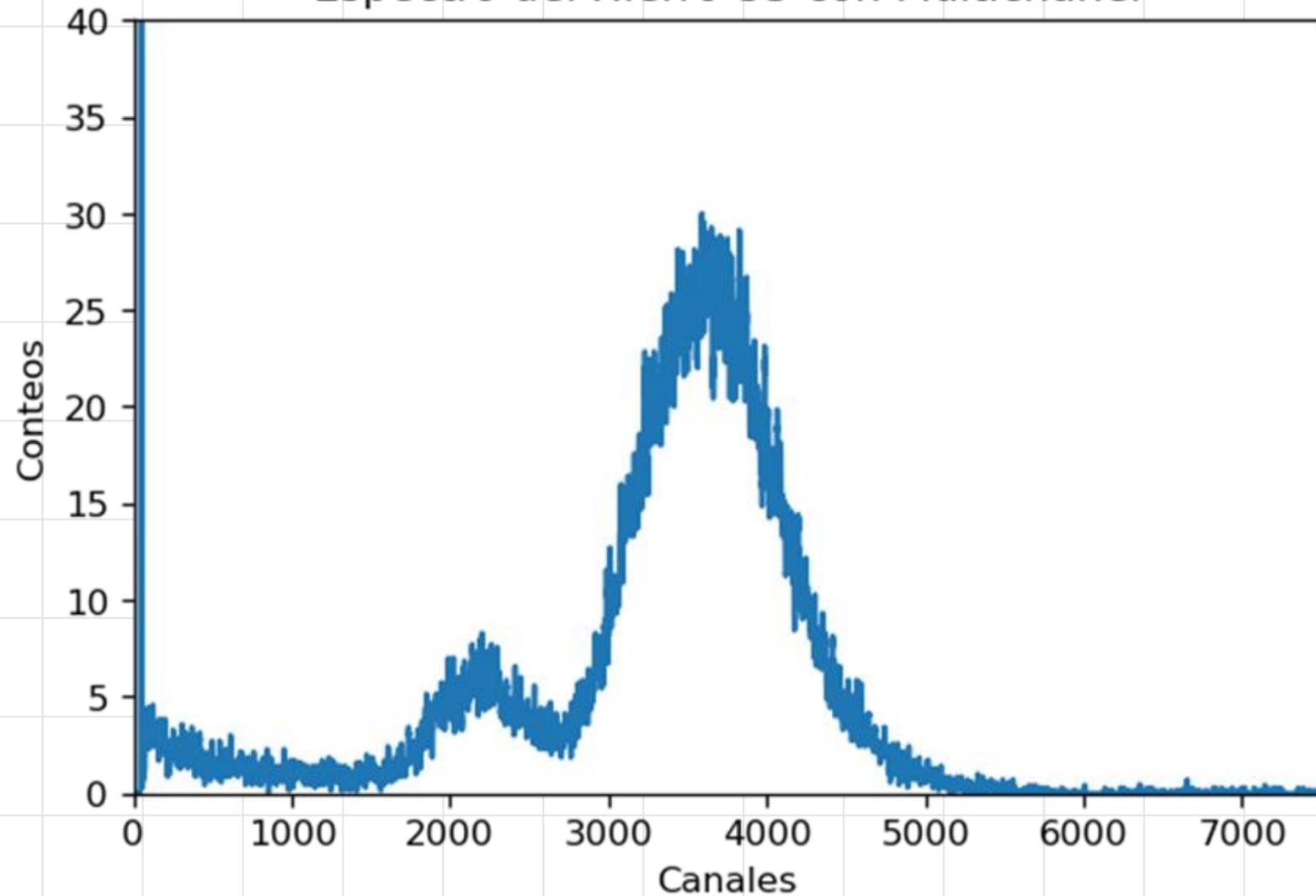




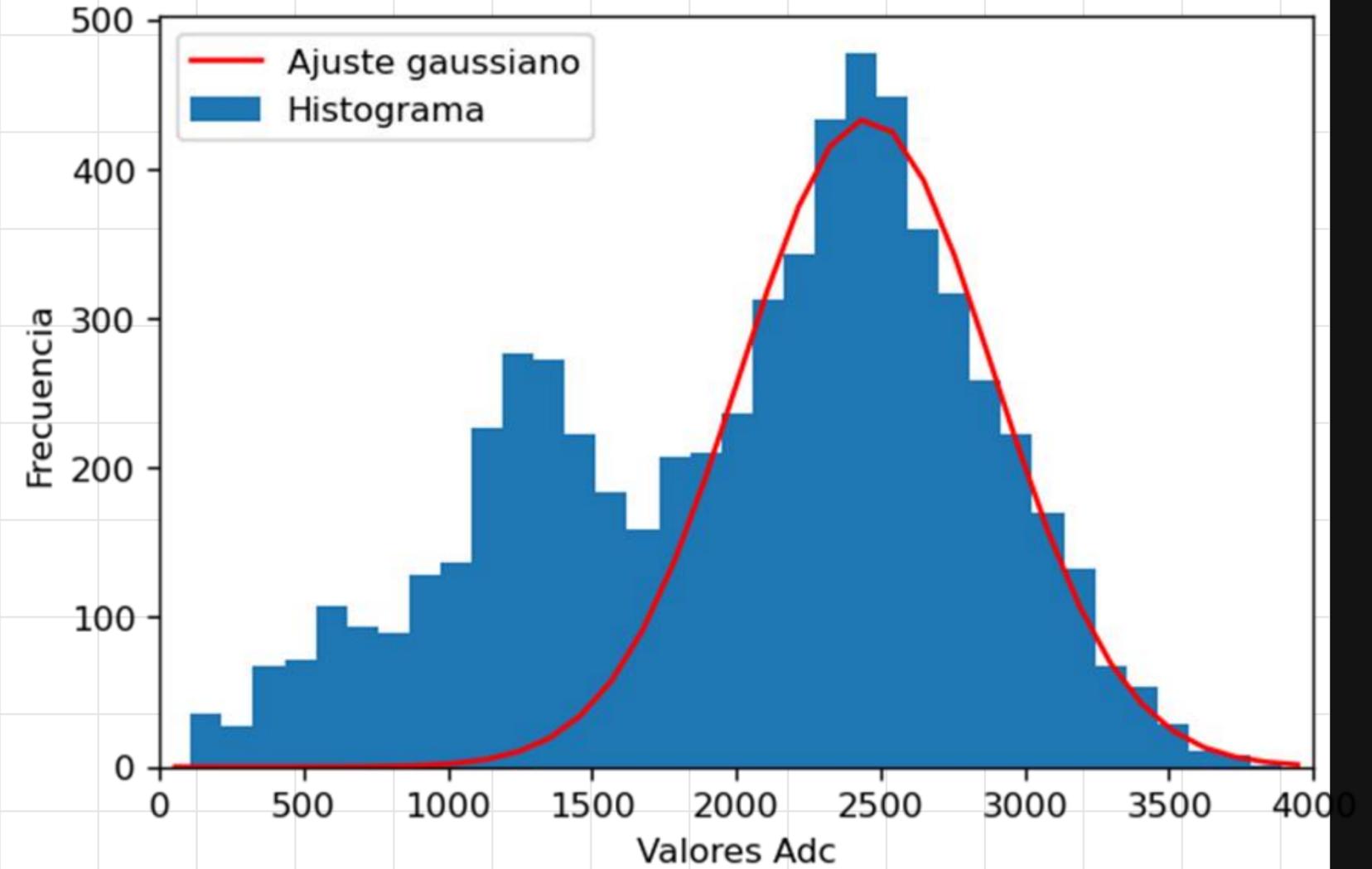


# Fuente Radiactiva Fe55

Espectro del Hierro-55 con Multichanel

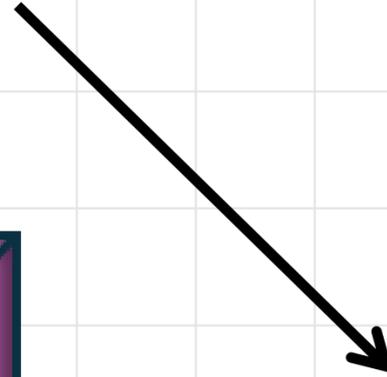
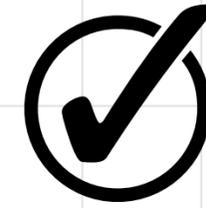


GEM 4



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

# Funciona

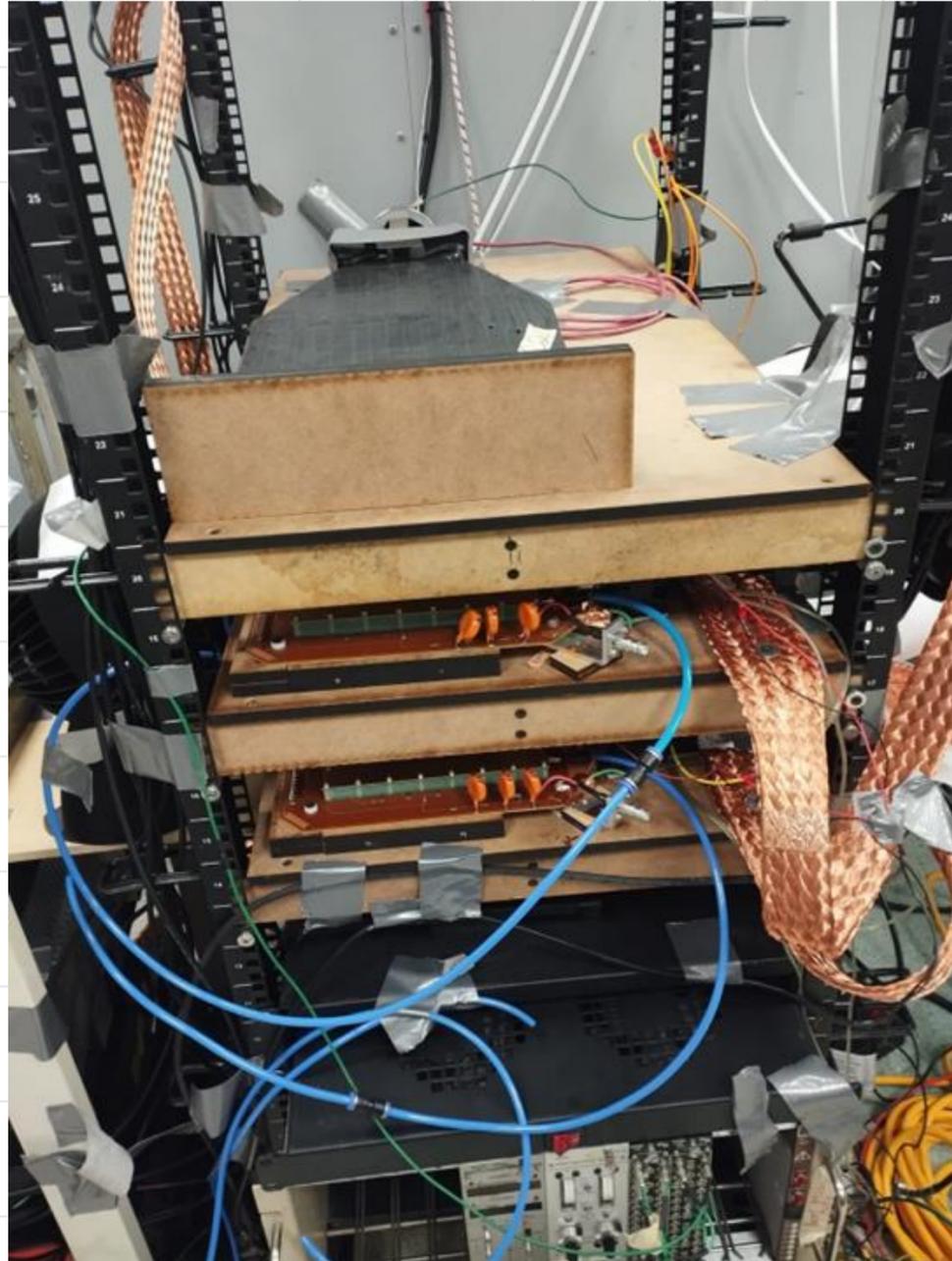


105.7  $MeV/c^2$   
-1  
2.2  
 $\mu s$   
 $\mu$   
muon

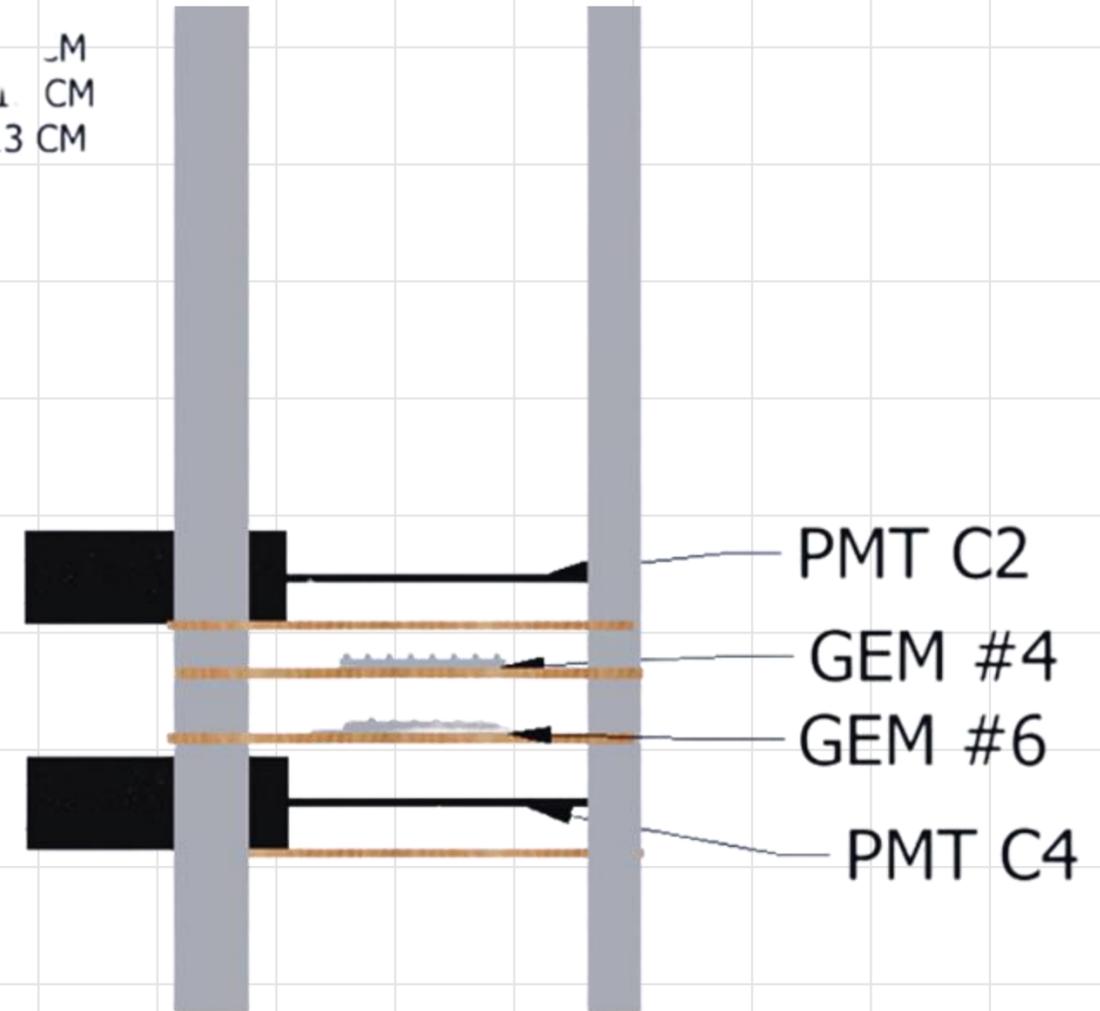
A 3D pink rectangular box with a dark blue outline. The box contains the following text: '105.7 MeV/c<sup>2</sup>' at the top, '-1' below it, '2.2' below that, 'μs' below that, a large Greek letter 'μ' in the center, and 'muon' at the bottom.

# *Muones*

# Montaje de Muones

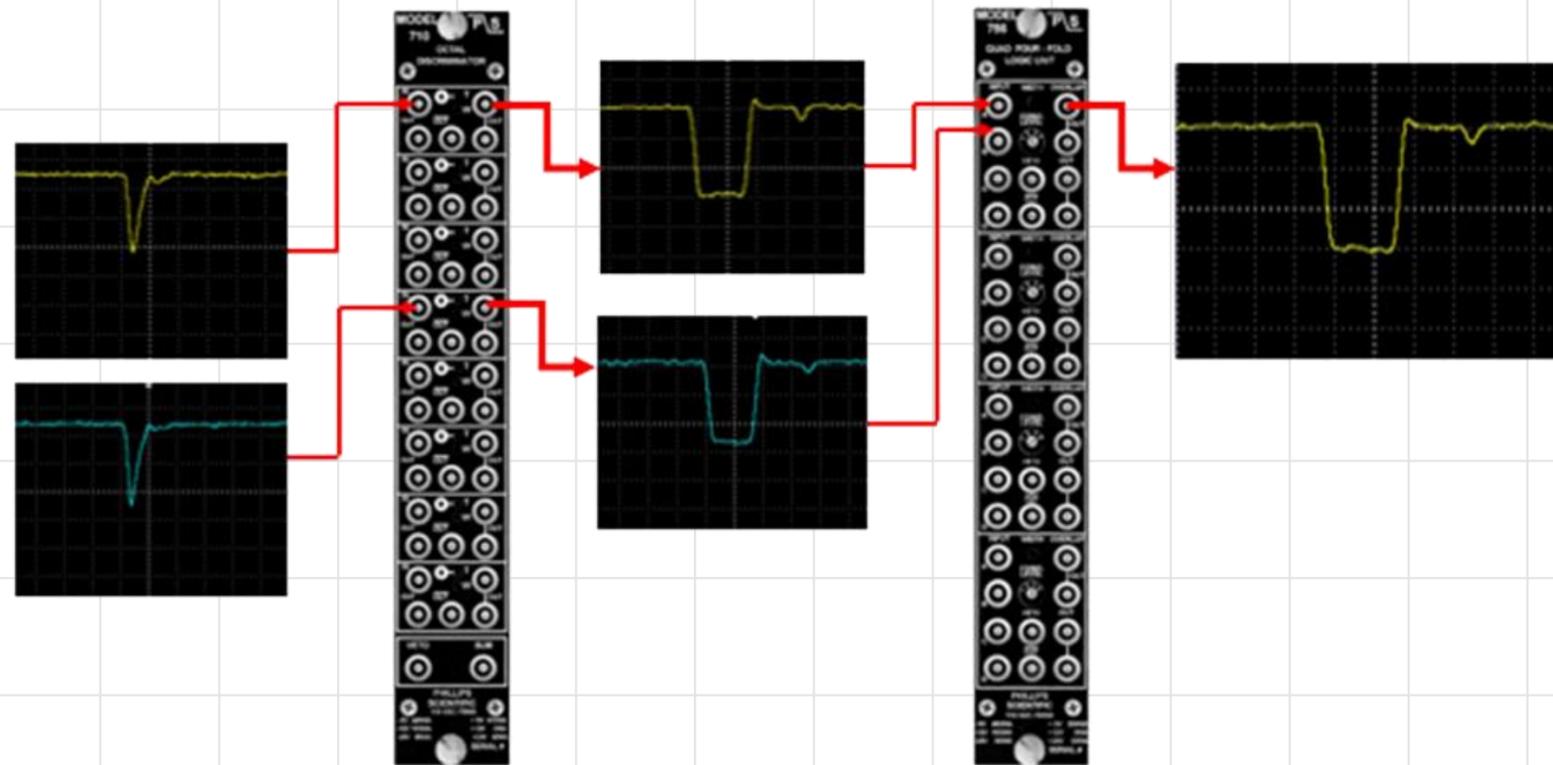


$\mu$   
D 1 CM  
D=13 CM



# Preparación PMT

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



*Umbral: 100 mV*

*Ventana Temporal: 20-25 ns*



# Muones

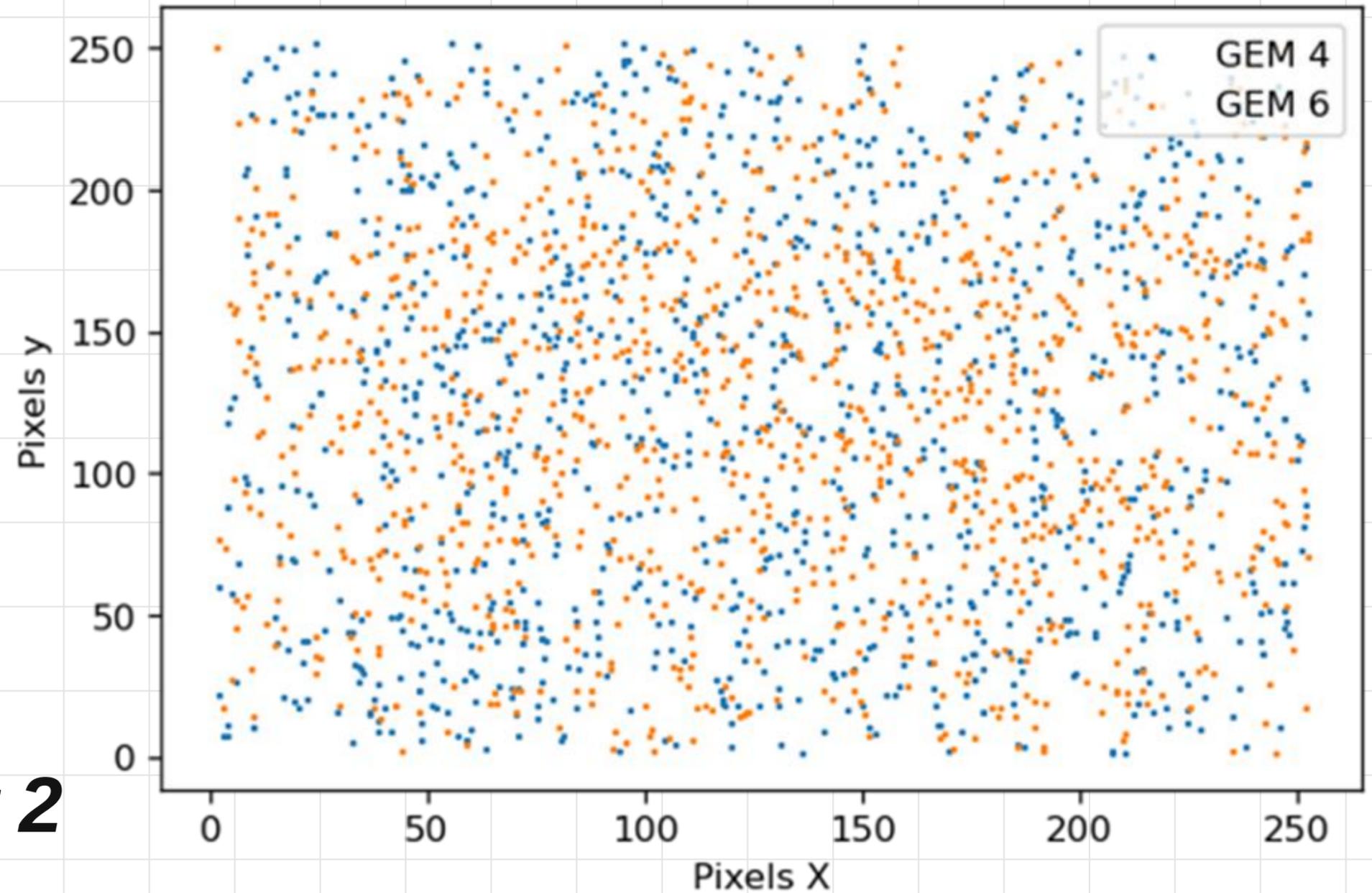
***Coincidencia Triple***

***Señal del Trigger***

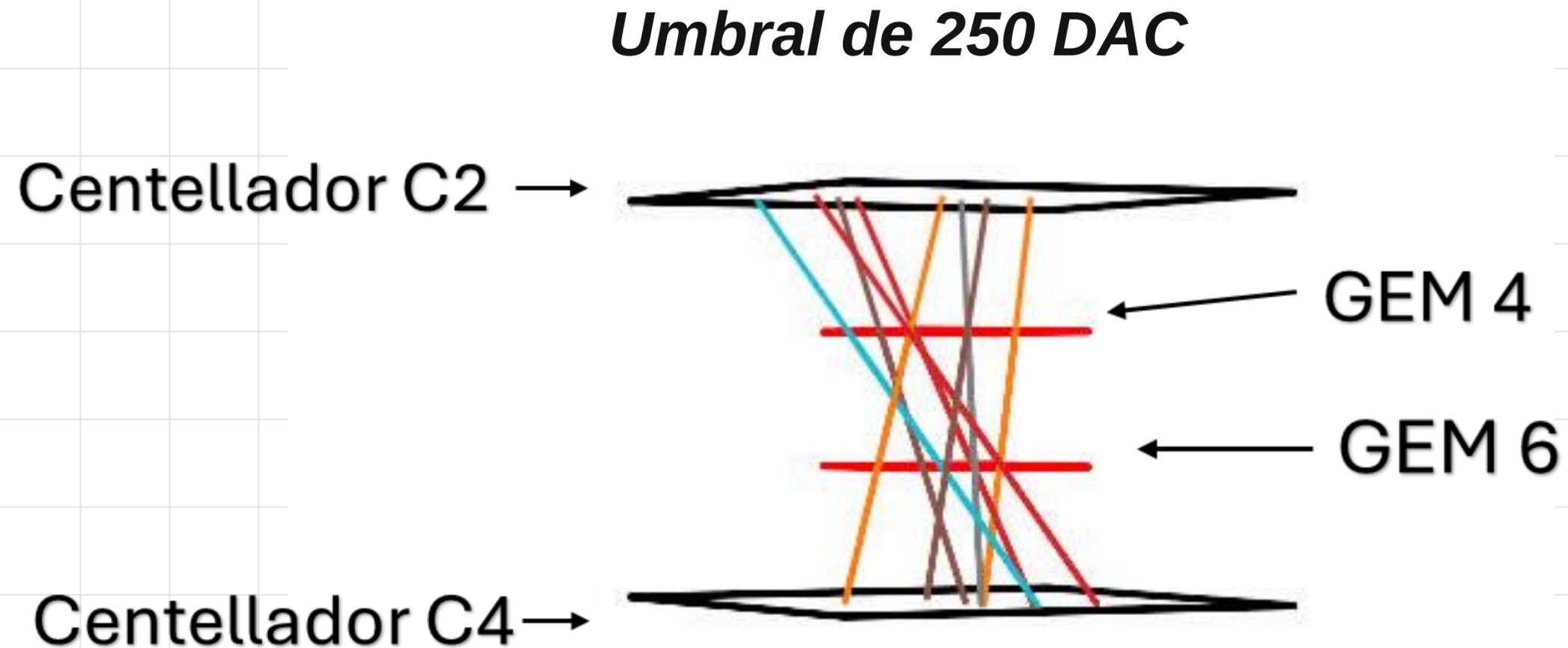
***$dt < 500 \text{ ns}$***

***Detector 1***

***Detector 2***

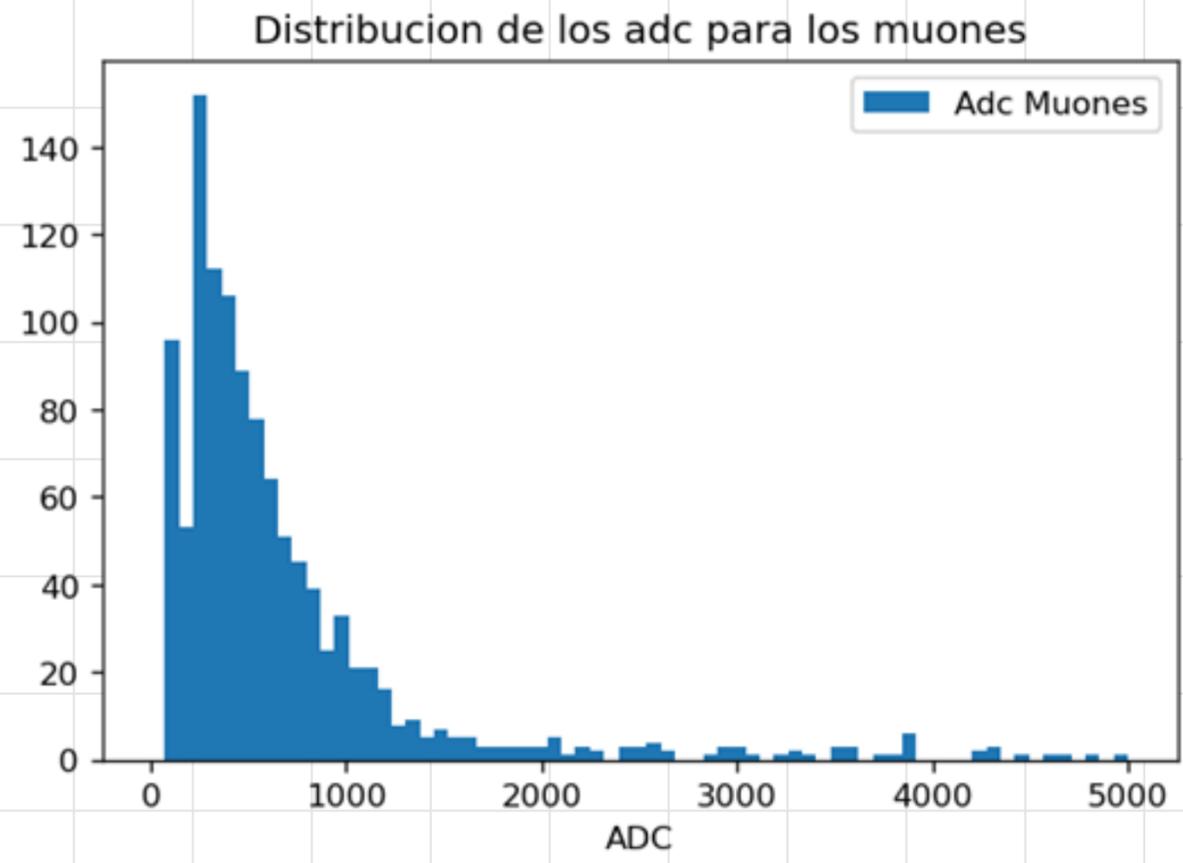
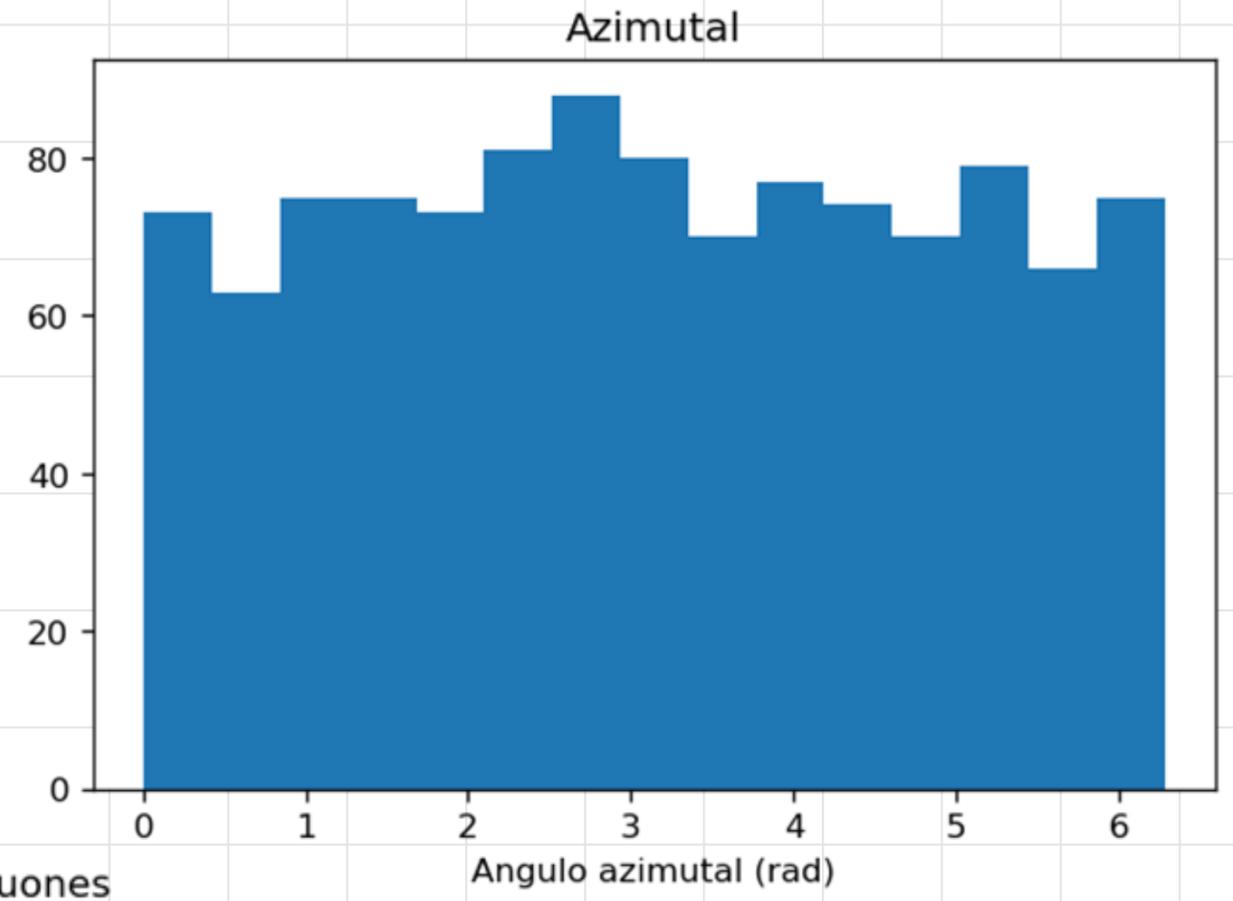
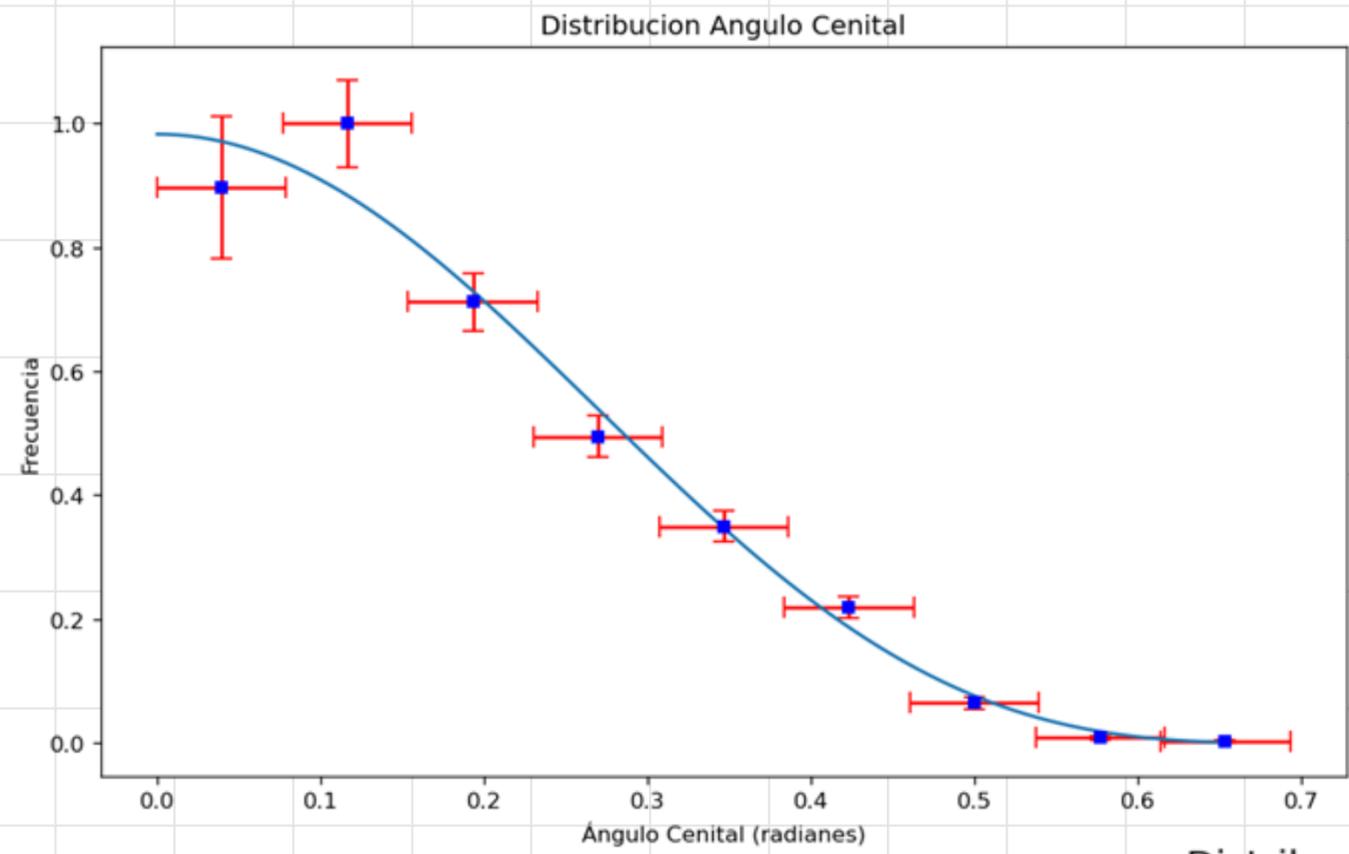


# Reconstrucción

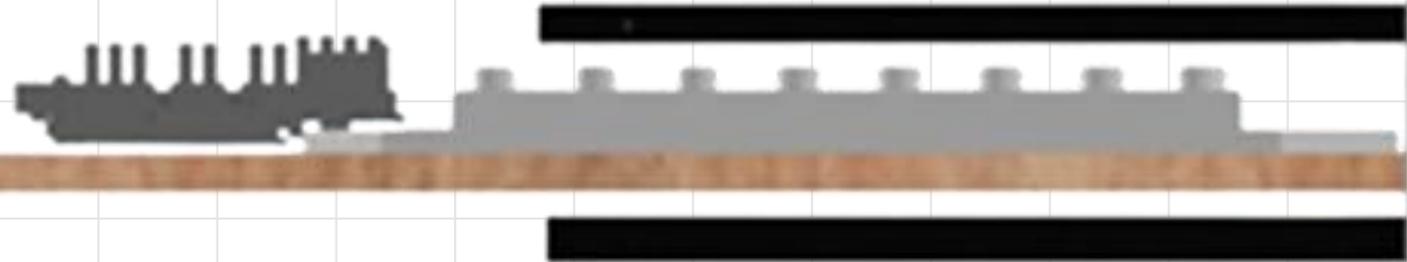
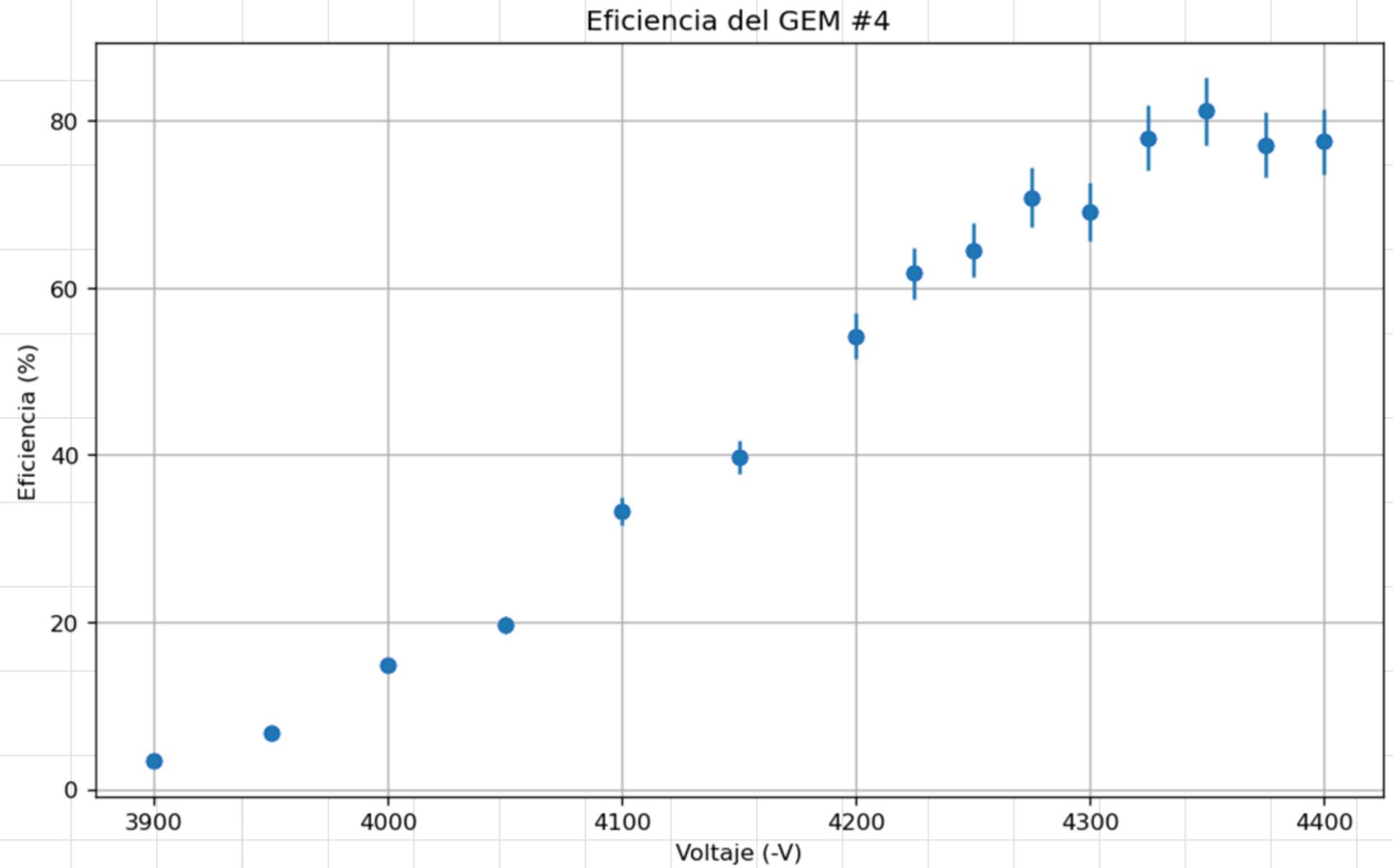


***1119 Coincidencias Triples***  
***31498 Señales PMT***

# Muones

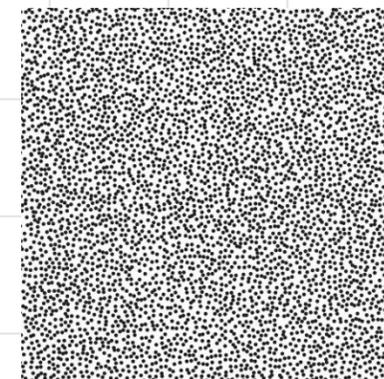
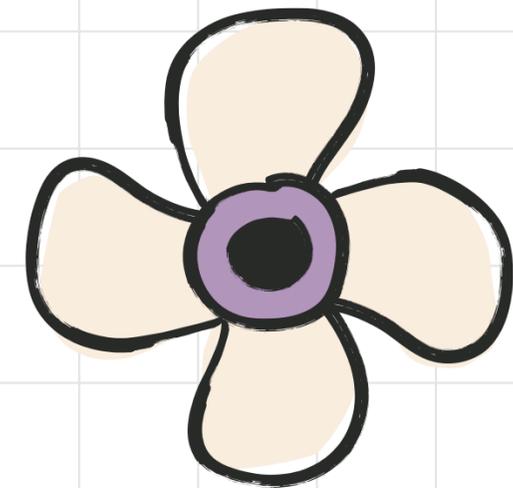


# Eficiencia



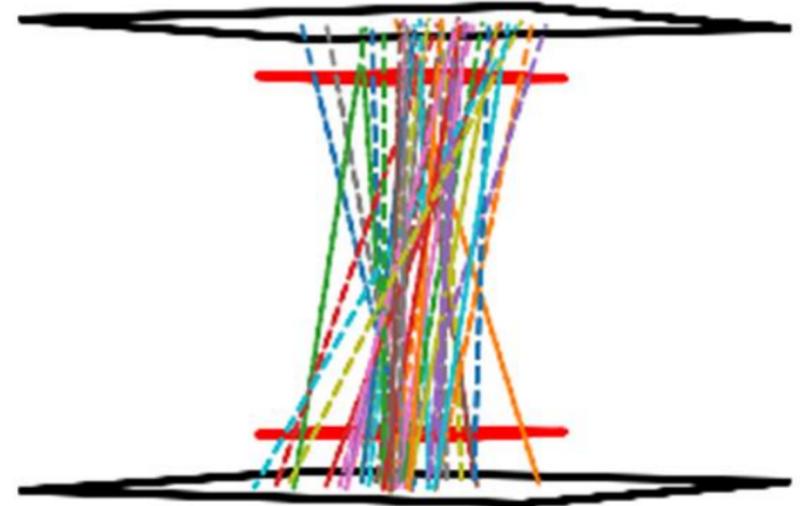
# Problemas Técnicos

- *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*

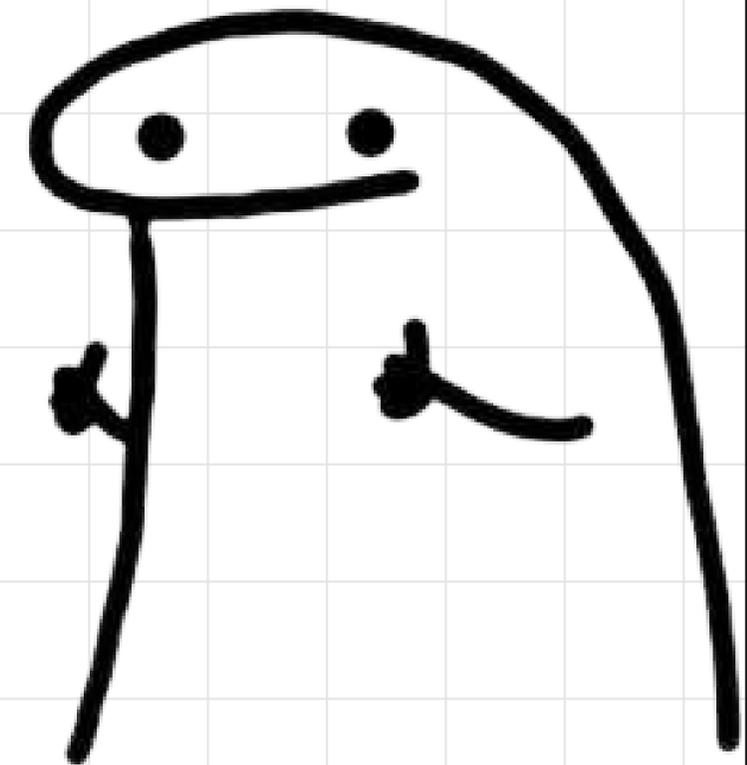


# Conclusiones

- ***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!

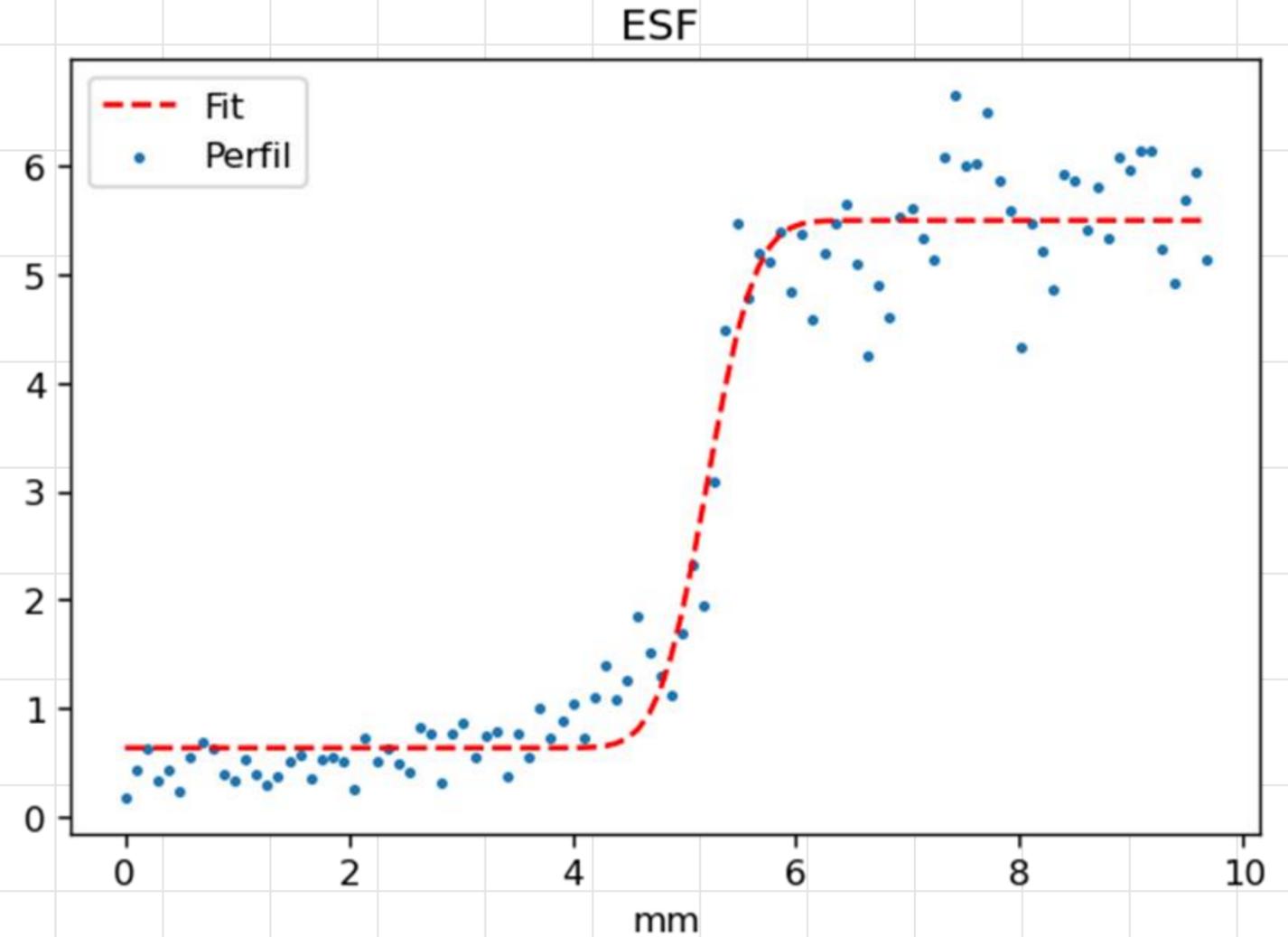
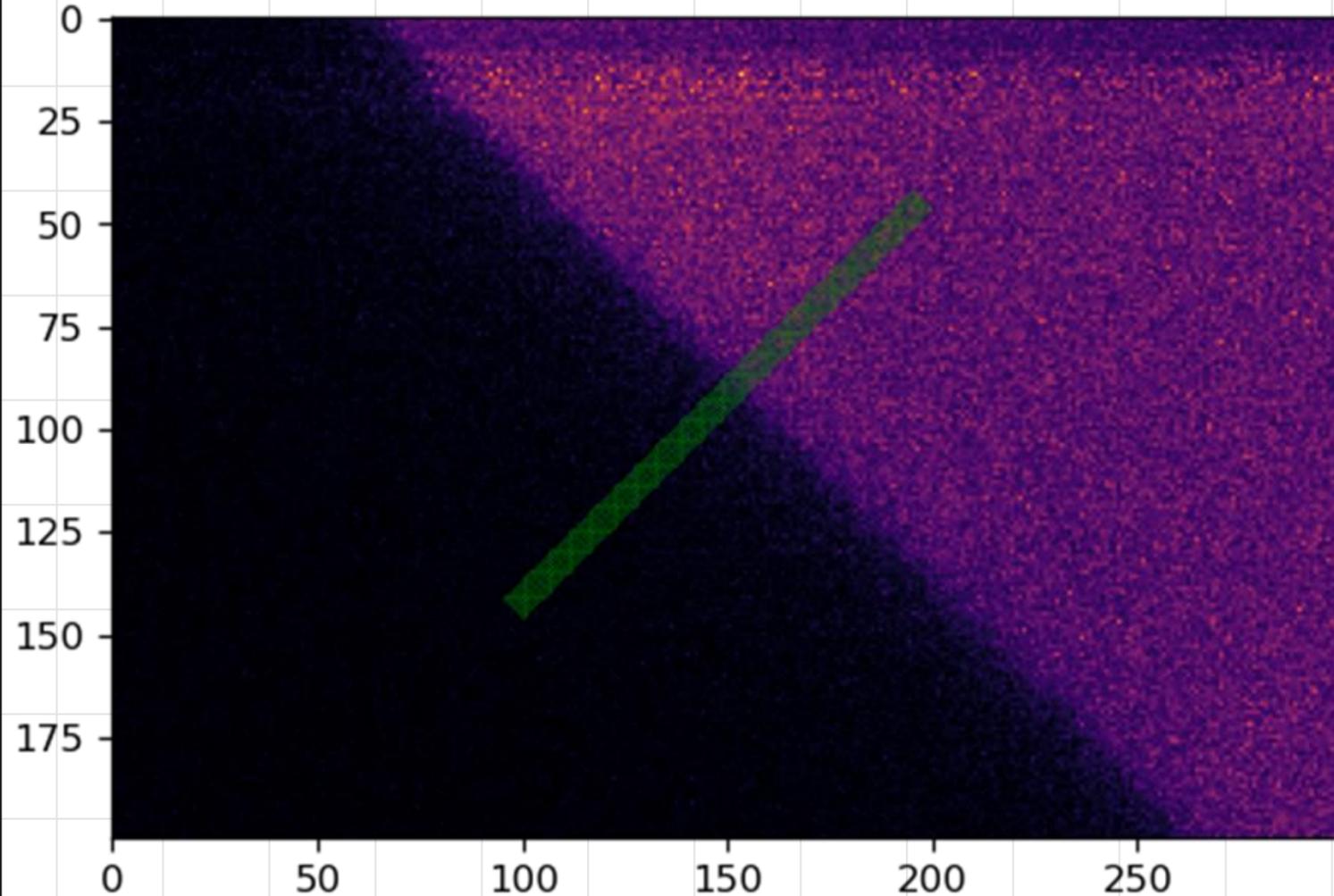


Si tienen preguntas adicionales me pueden  
escribir:

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

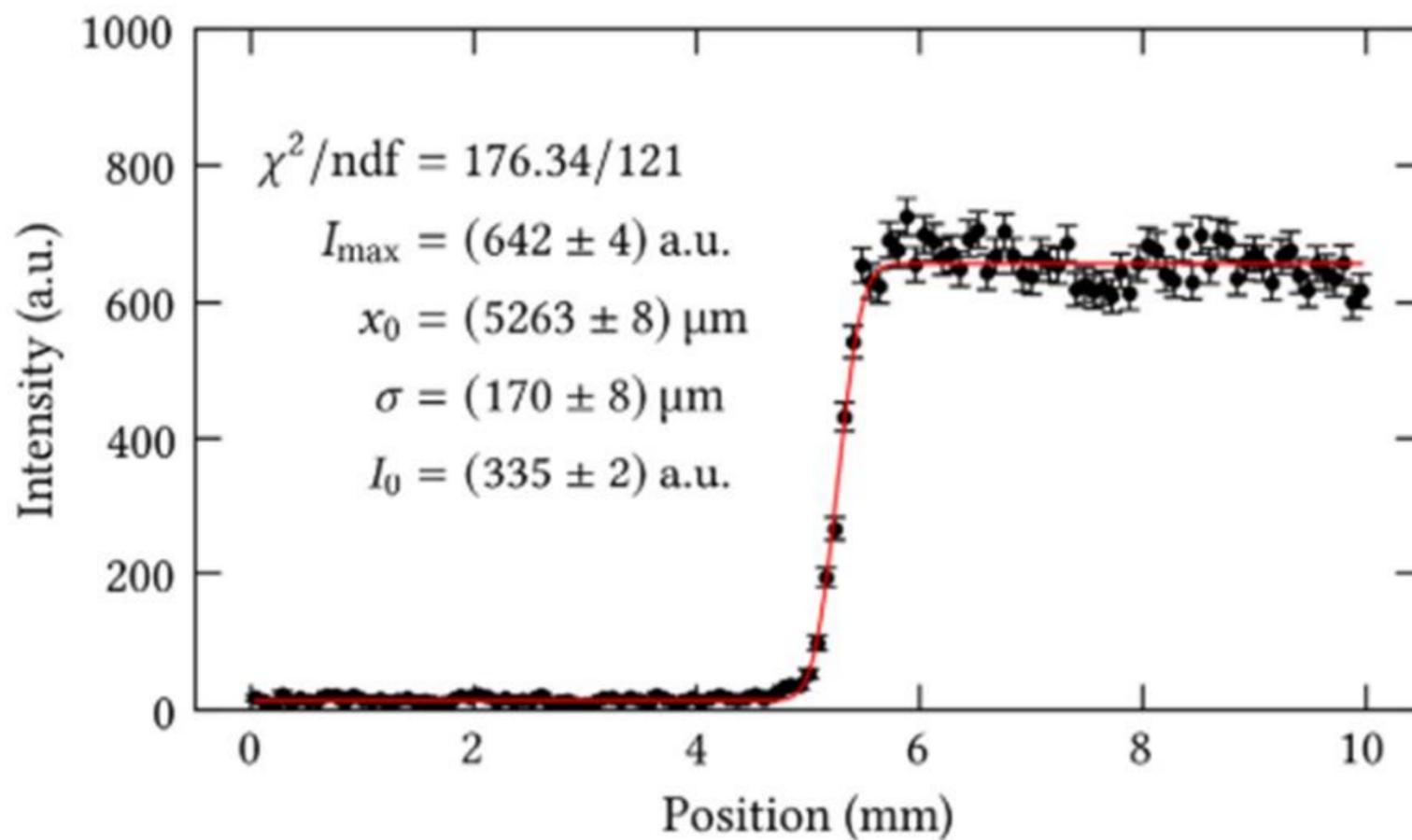
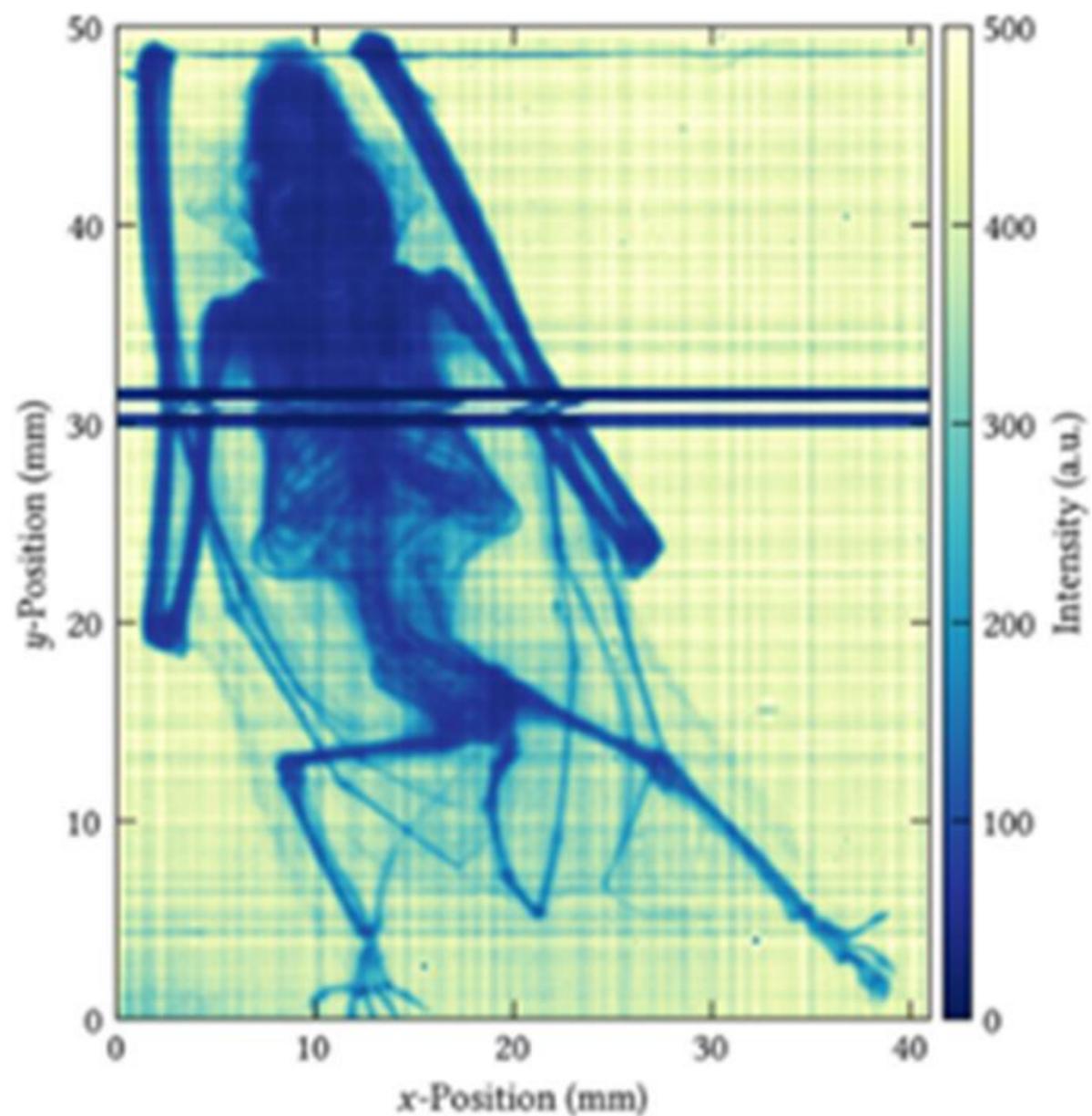
# Resolución Espacial

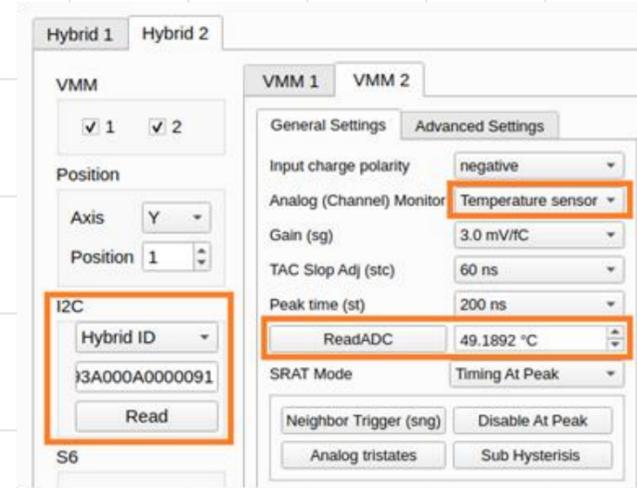
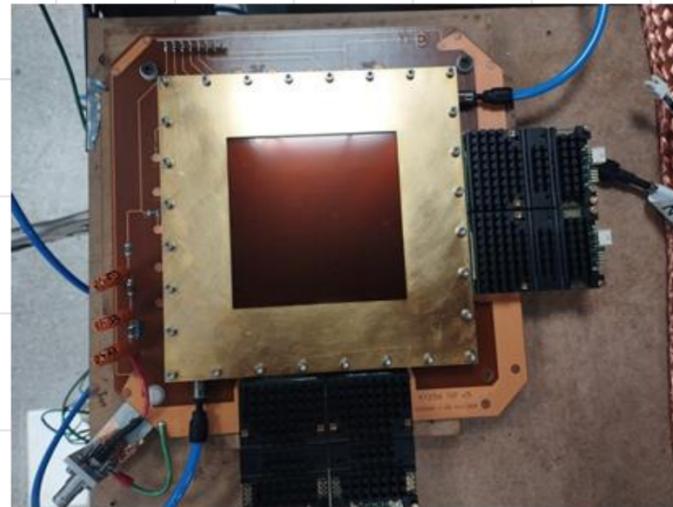
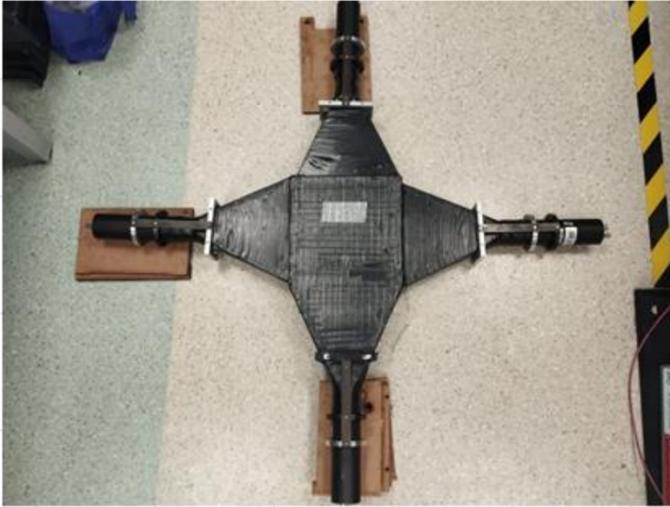
$$I(x) = I_0 + \frac{I_{max}}{2} \operatorname{erf} \left( \frac{x-x_0}{\sqrt{2}\sigma} \right)$$



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

# Estado del Arte





```
try:
args = ['/home/labhep/sw/vmm-sdat/bin/convertFile',
'-f', current_directory+'/'+PMT1600V_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', '[[[5,7,82],[5,7,82]]]',
'-bc', '40',
'-tac', '60',
'-th', '0',
'-cs', '1',
'-ccs', '2',
'-dt', '200',
'-mst', '2',
'-spc', '500',
'-dp', '200',
'-coin', 'center-of-mass',
'-crl', '0.5',
'-cru', '2',
'-save', '[[[1,2],[1,2],[1,2]]]',
'-stats', '1',
```

Voltaje PMT -2000V

Voltaje -3800V  
a -4200V

Umbral 300 DAC

Default

Umbral 100 mV

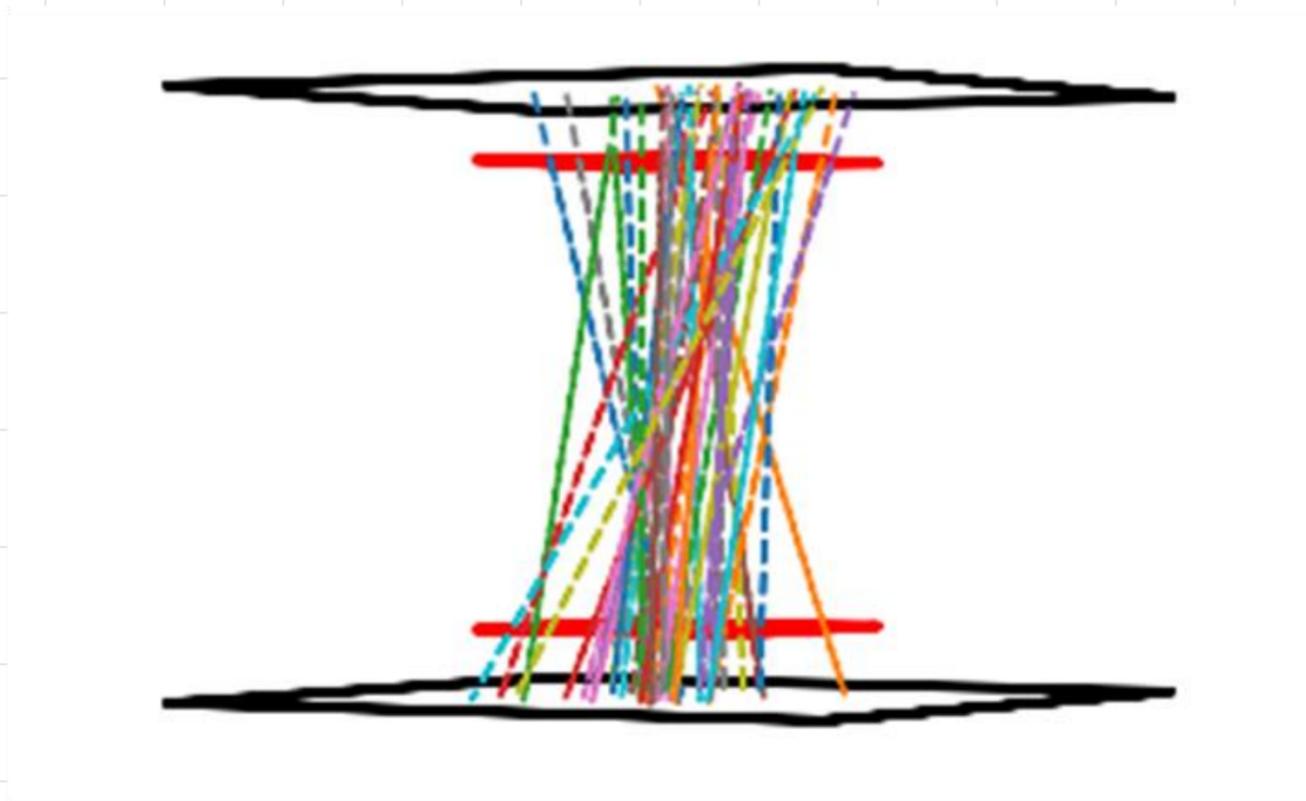
Ganancia 3 mv/fc

Ancho Coincidencia  
25 ns

Peak Time 200 ns

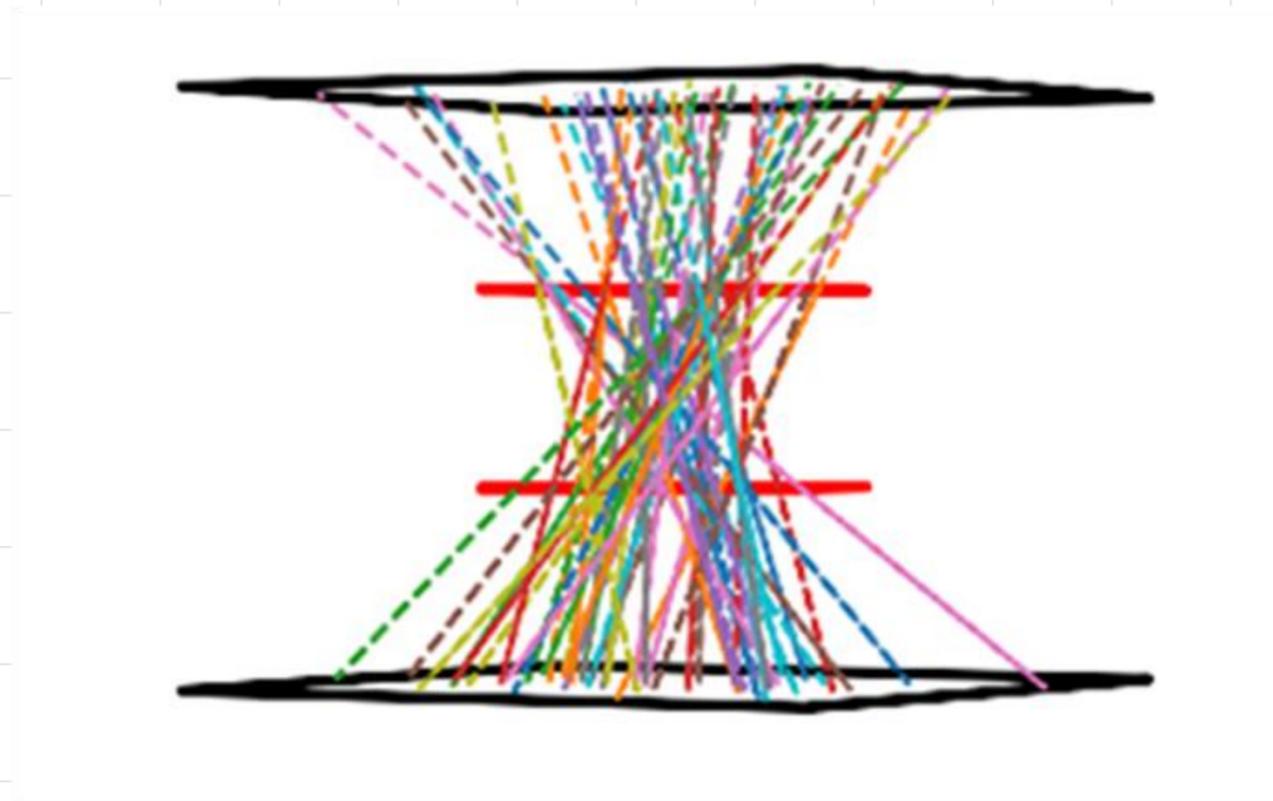
# Muones

GEM separados 1 m



40 Coincidencias Triples

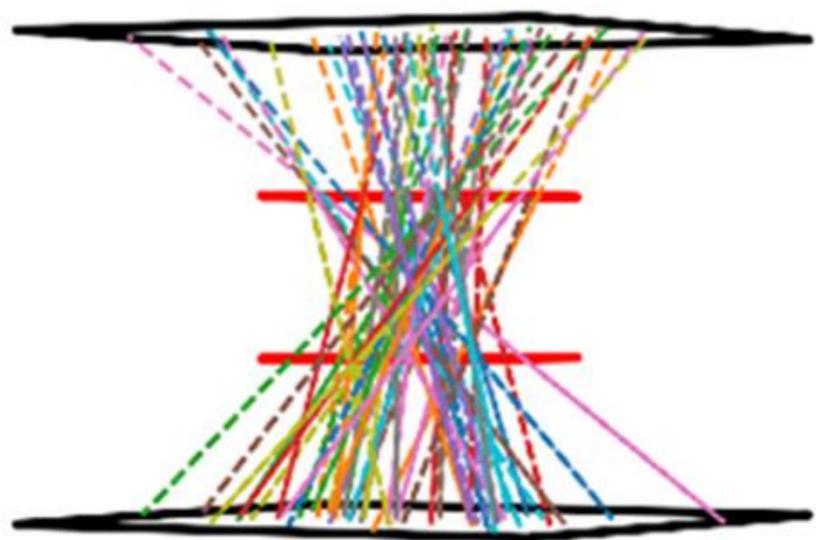
GEM separados 15 cm



449 Coincidencias Triples

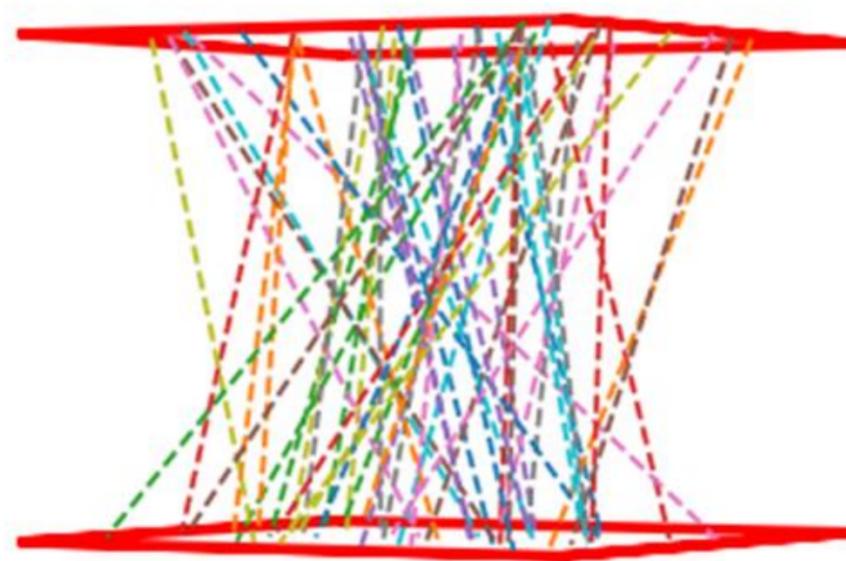
# Muones

Coincidencia Triple



449 Coincidencias Triples

Coincidencia Doble



508 Coincidencias Triples