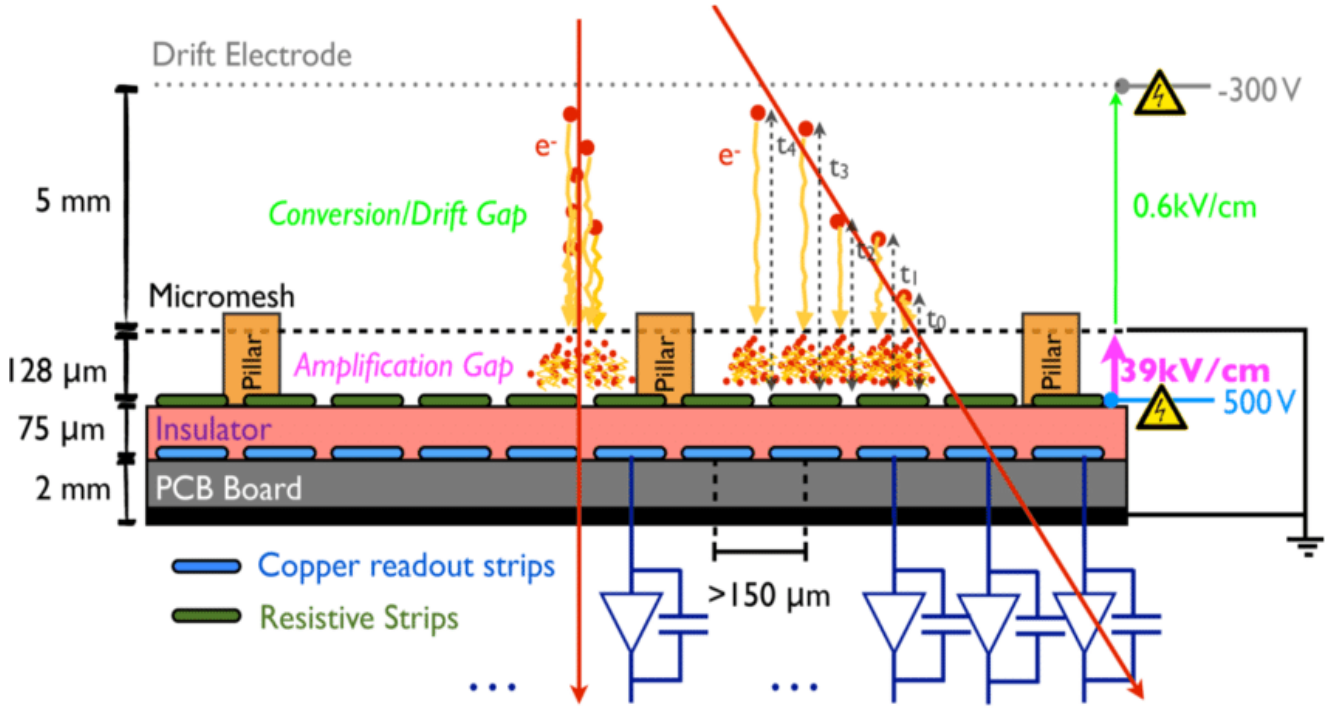
The Resistive Micromegas – Lab 2

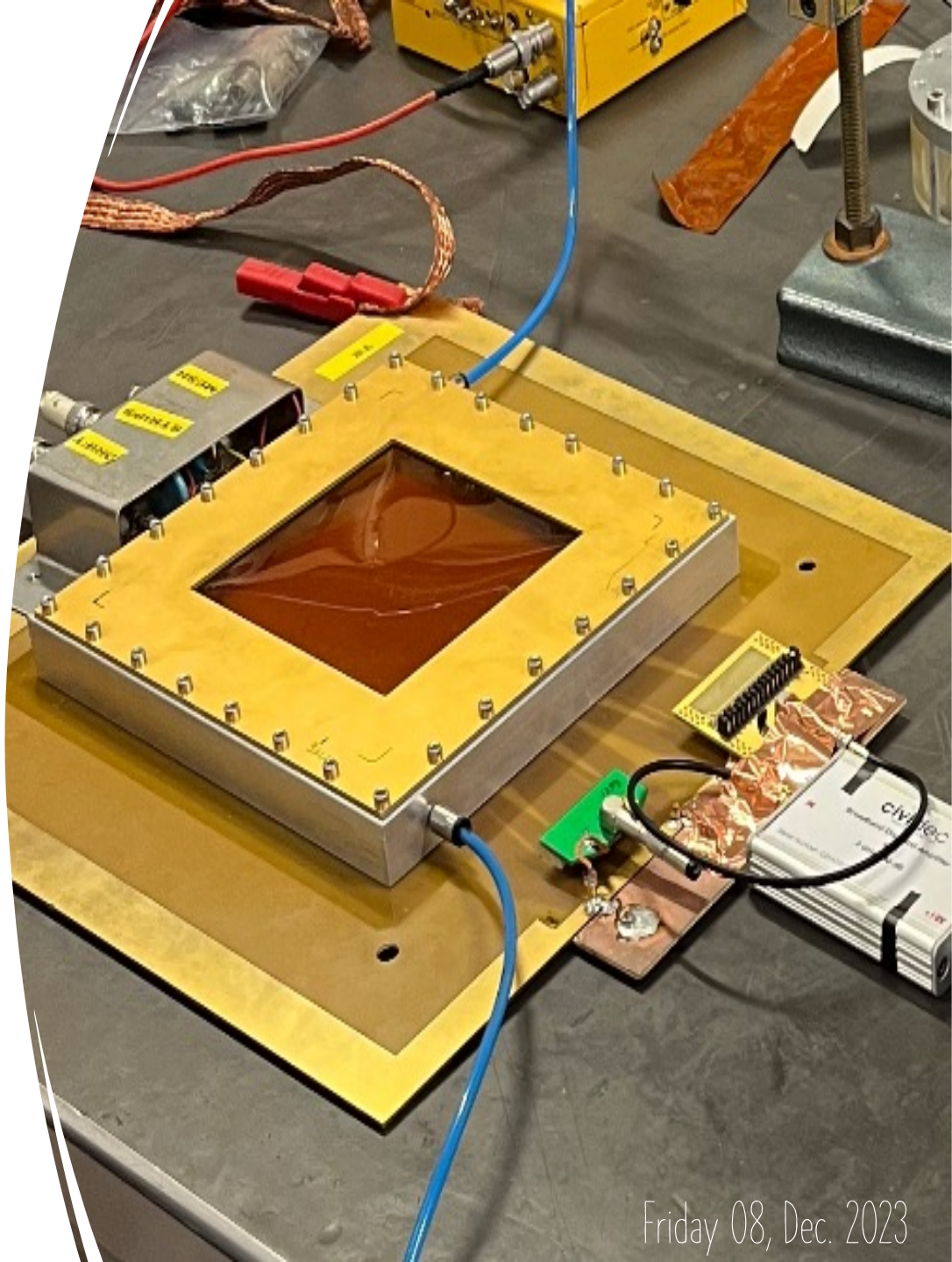
Group 1: Efstathios Karentzos, Matteo Giovannetti, Miranda Rabelhofer, Richa Rai

Outlines

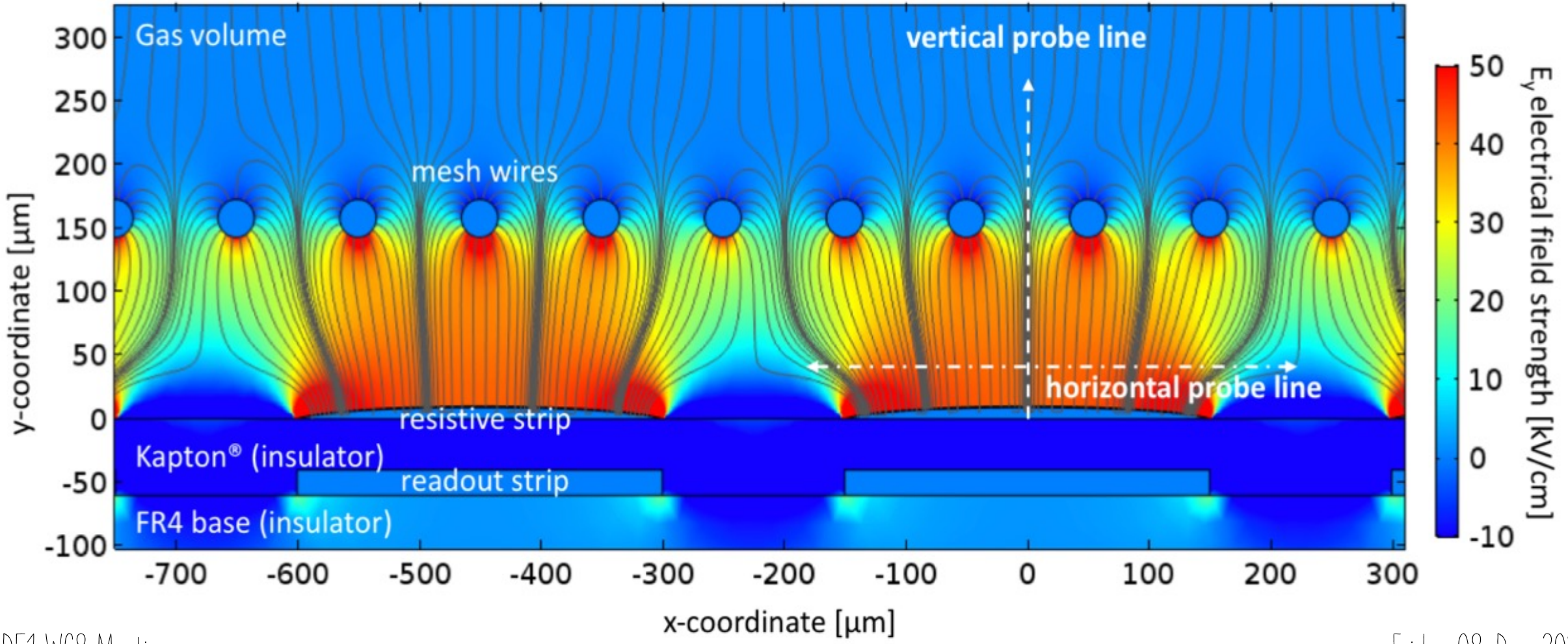
- The resistive Micromegas!
- Experimental Setup
- ^{55}Fe source
- 1st measurements: Noise vs Signal
- Gain
- ADC Spectrum
- Energy Resolution

The Resistive Micromegas

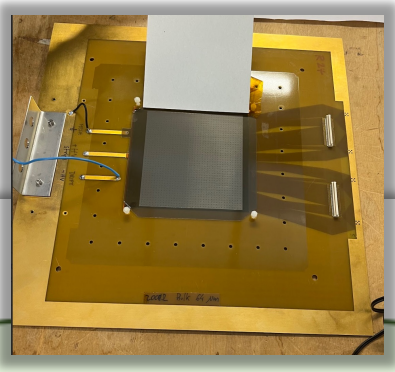


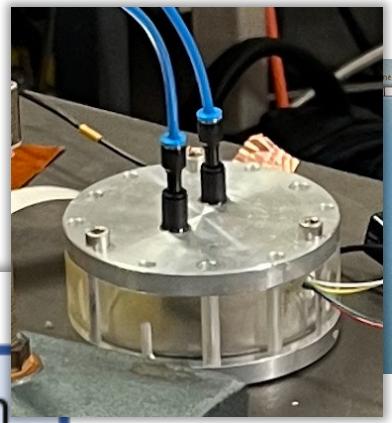


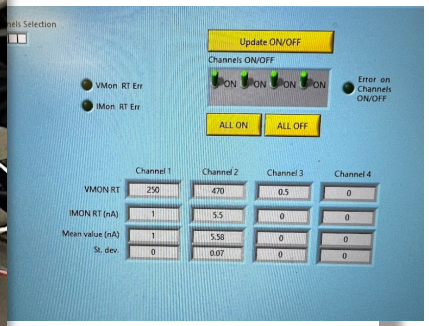
E field strength simulation



Experimental Setup







Gas distribution system

HV power supply

IN

Detector

OUT

Gas distribution system

FAST readout chain

SIGNAL

SLOW readout

Micromegas

Charge preamplifier+Shaper + AMTEK MCA (4096 chans.)

CAEN modules (N/P)

+LabView tool for HV manipulation and monitoring!

^{55}Fe Source

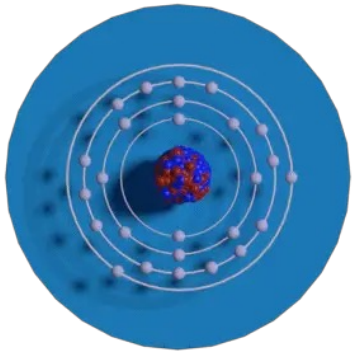
Fe
Iron

Atomic number
protons / electrons
26

Neutrons
(most common isotope)
30

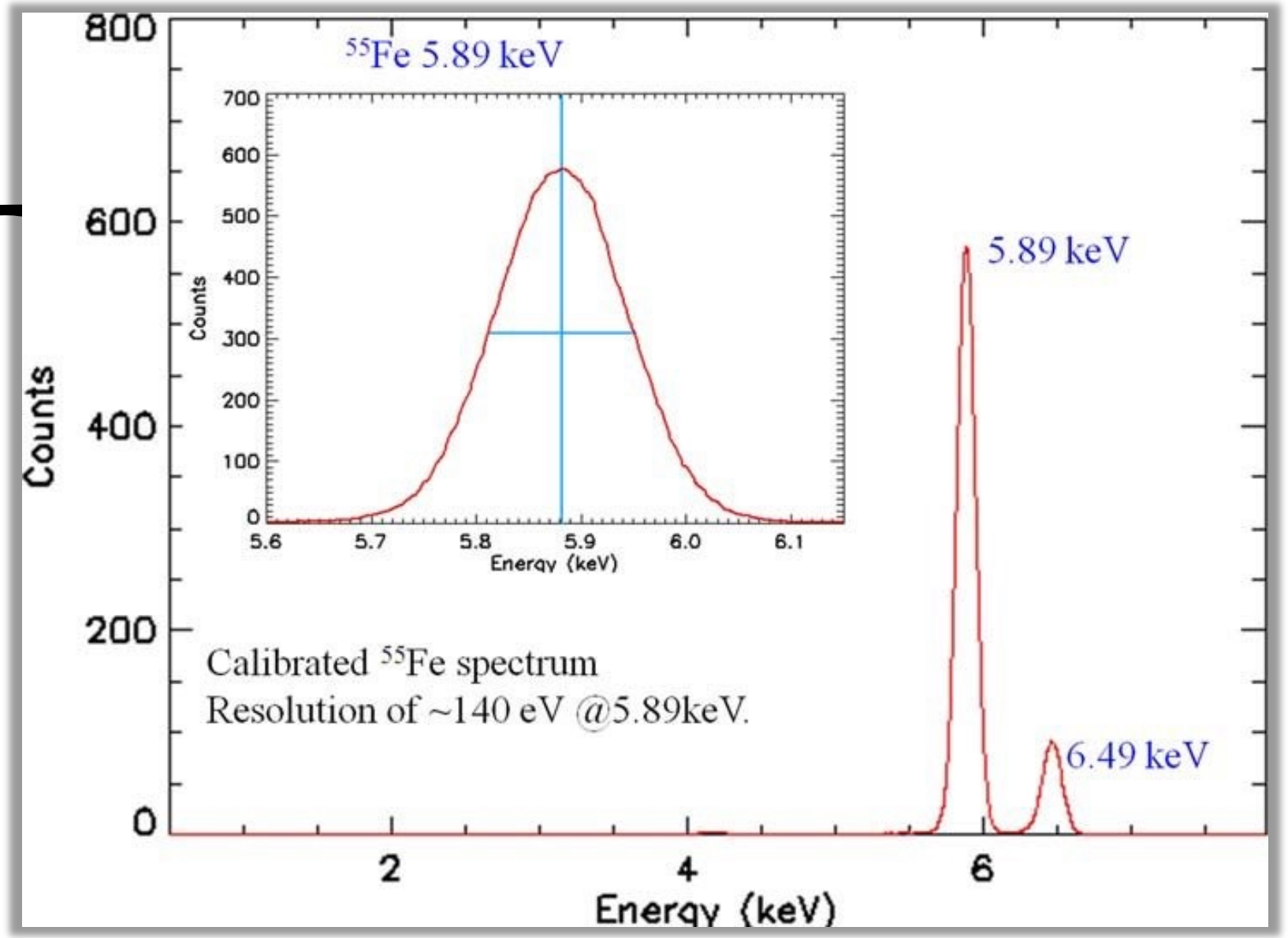
Atomic weight
(amu)
55.85

Atomic radius
(pm)
132

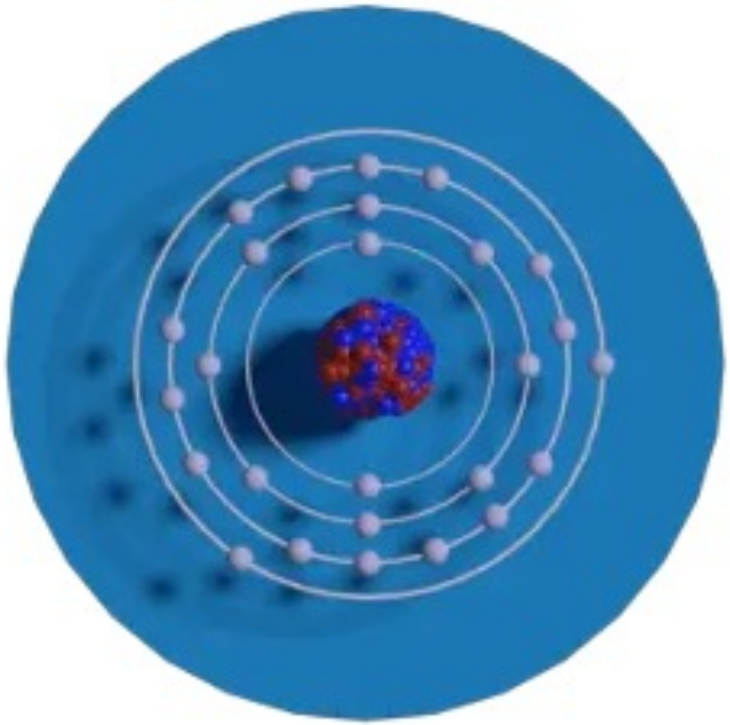


[Ar] 3d6 4s2

7s □ 7p□□□
6s □ 6p□□□ 6d□□□□□
5s □ 5p□□□ 5d□□□□□ 5f□□□□□□□
4s ↿⇂ 4p□□□ 4d□□□□□ 4f□□□□□□□
3s ↿⇂ 3p ↿⇂ ↿⇂ 3d ↿ ↿ ↿ ↿ ↿
2s ↿⇂ 2p ↿⇂ ↿⇂
1s ↿⇂



^{55}Fe Source



^{55}Fe

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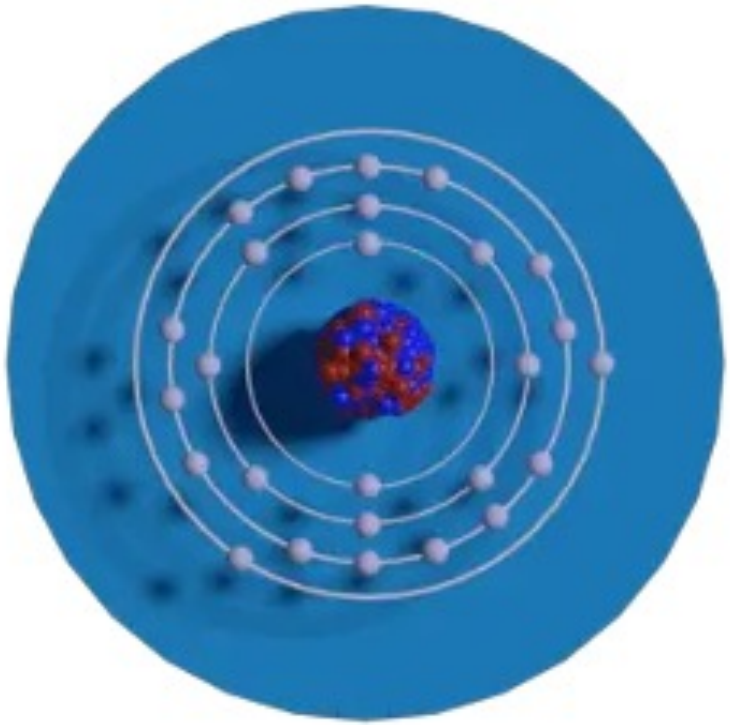
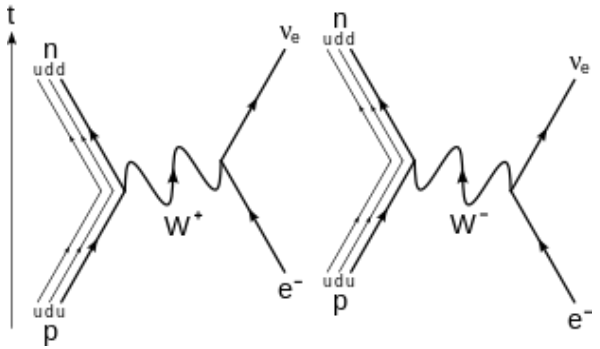
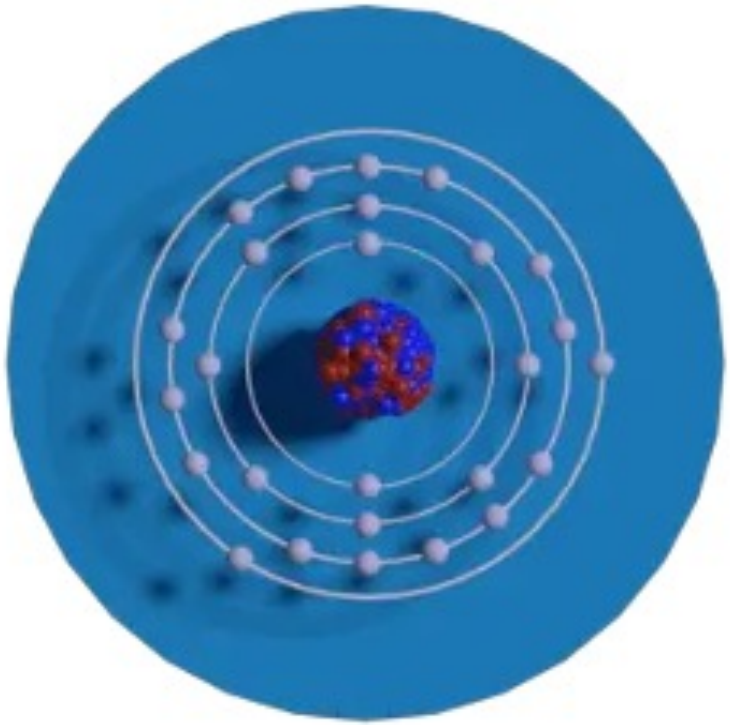


^{55}Fe

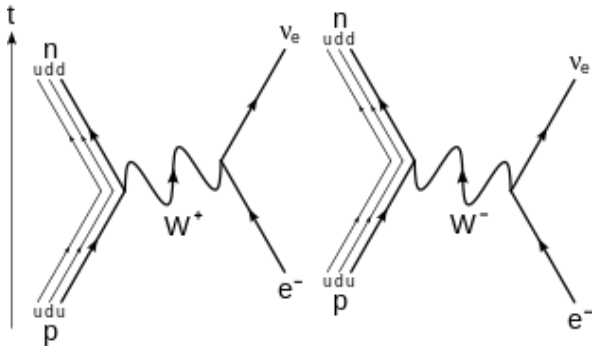


Capture e^- from K-shell

^{55}Fe Source



^{55}Fe



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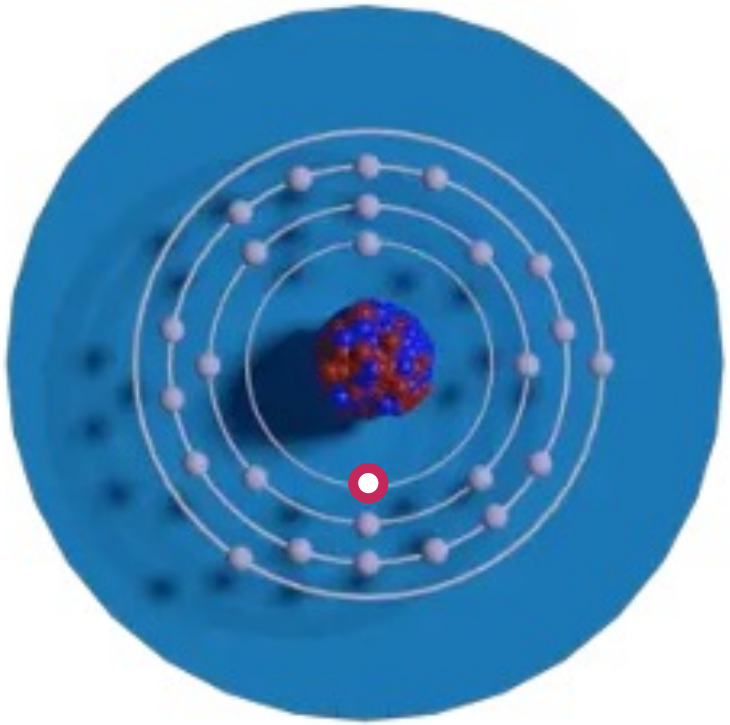
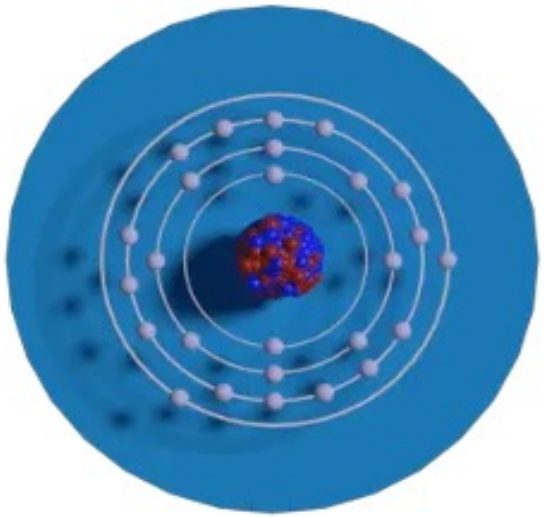
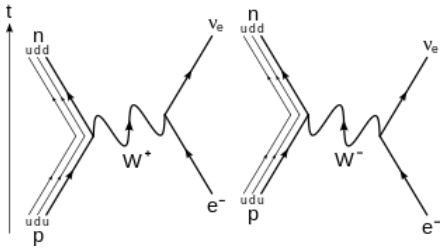


^{55}Mn

^{55}Fe Source



^{55}Fe



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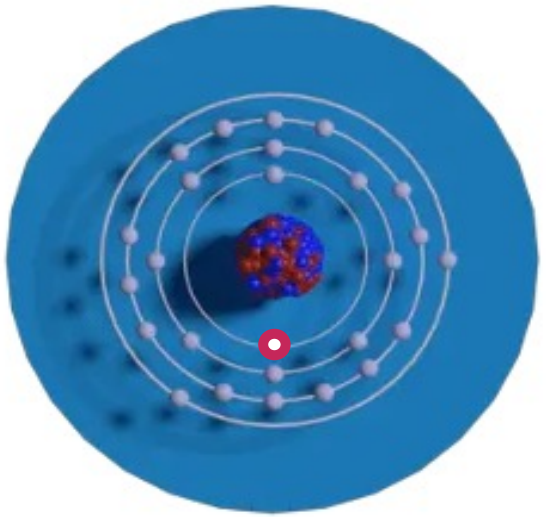


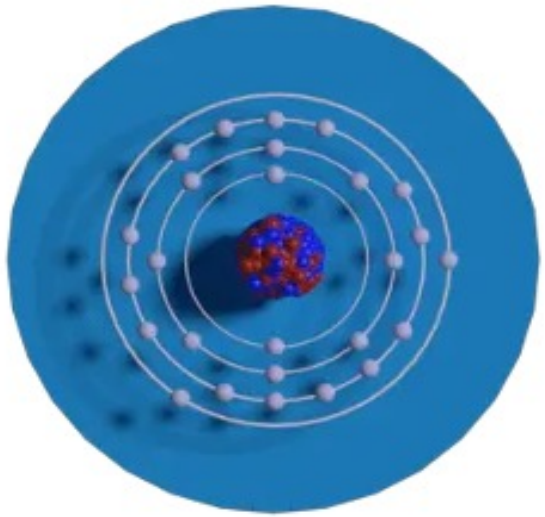
^{55}Mn

De-energization

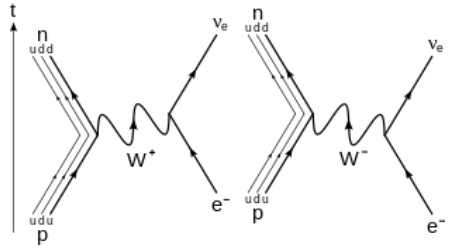
e^-_{auger}	5,19keV	[60%]
K_{a1} X-ray	5,9 keV.	[16.2%]
K_{a2} X-ray	5,9 keV.	[8.2%]
K_b X-ray	6,49 keV.	[2.9%]

Rest [%]: low-E e^-_{auger} & γ

^{55}Fe Source



^{55}Fe



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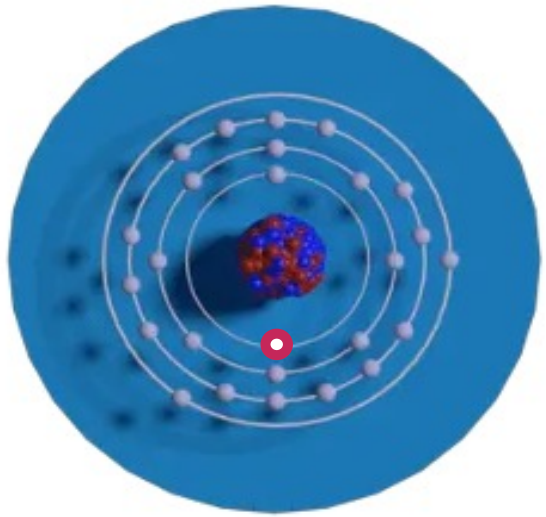

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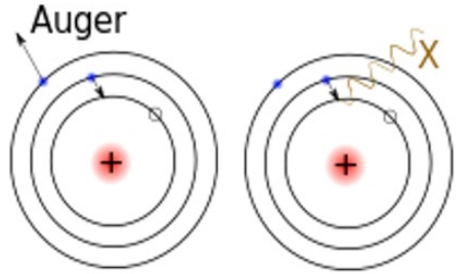


Argon (mixture) interactions

1. γ+Ar => Ar* + 2e- [85%]
   - e^-_{auger} 2.6 keV
   - e^-_{photo} 2.7 keV

2. γ+Ar => Ar* + e- + γ [15%]
   - e^-_{photo} 2.6 keV
   - γ 2.9-3.2 keV

Familiarity and 1st measurements

- Gas against purity level, connection, flow, environmental conditions and humidity!

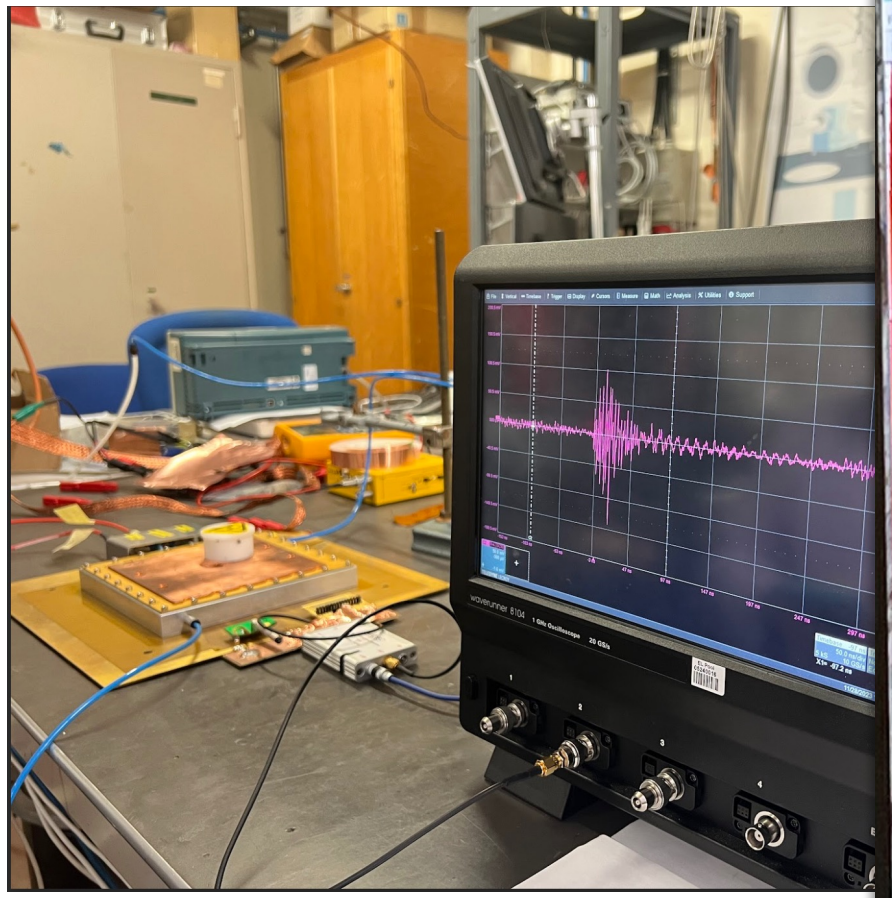
  Mixture: $Ar/CO_2/iC_4H_{10}$ (93:5:2), Humidity ~ 18%

- HV settings: V_{strips} = 470V, V_{mesh} = 0, V_{drift} = −250V
- Noise (20 mV) measurements and mitigation techniques: grounding, shielding, triggering!

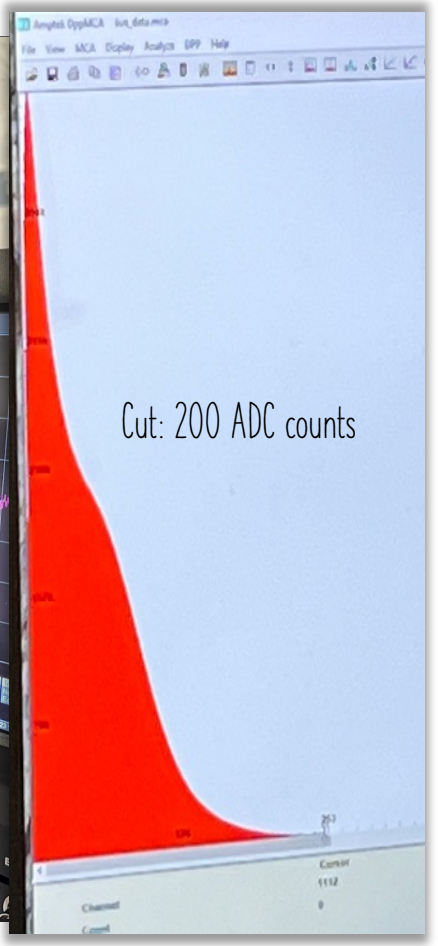
  I_{dark} = 2.58 nA

Source characteristics:

Rate = 8.6kHz, I_{source} = 5.33 nA

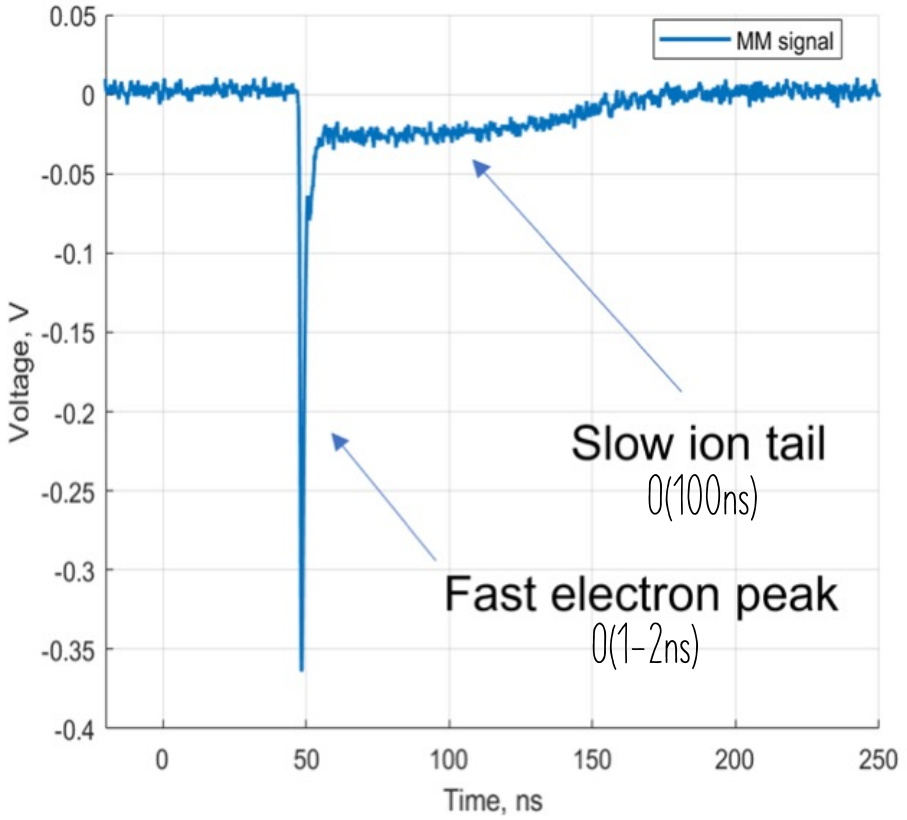


Chasing the Noise!

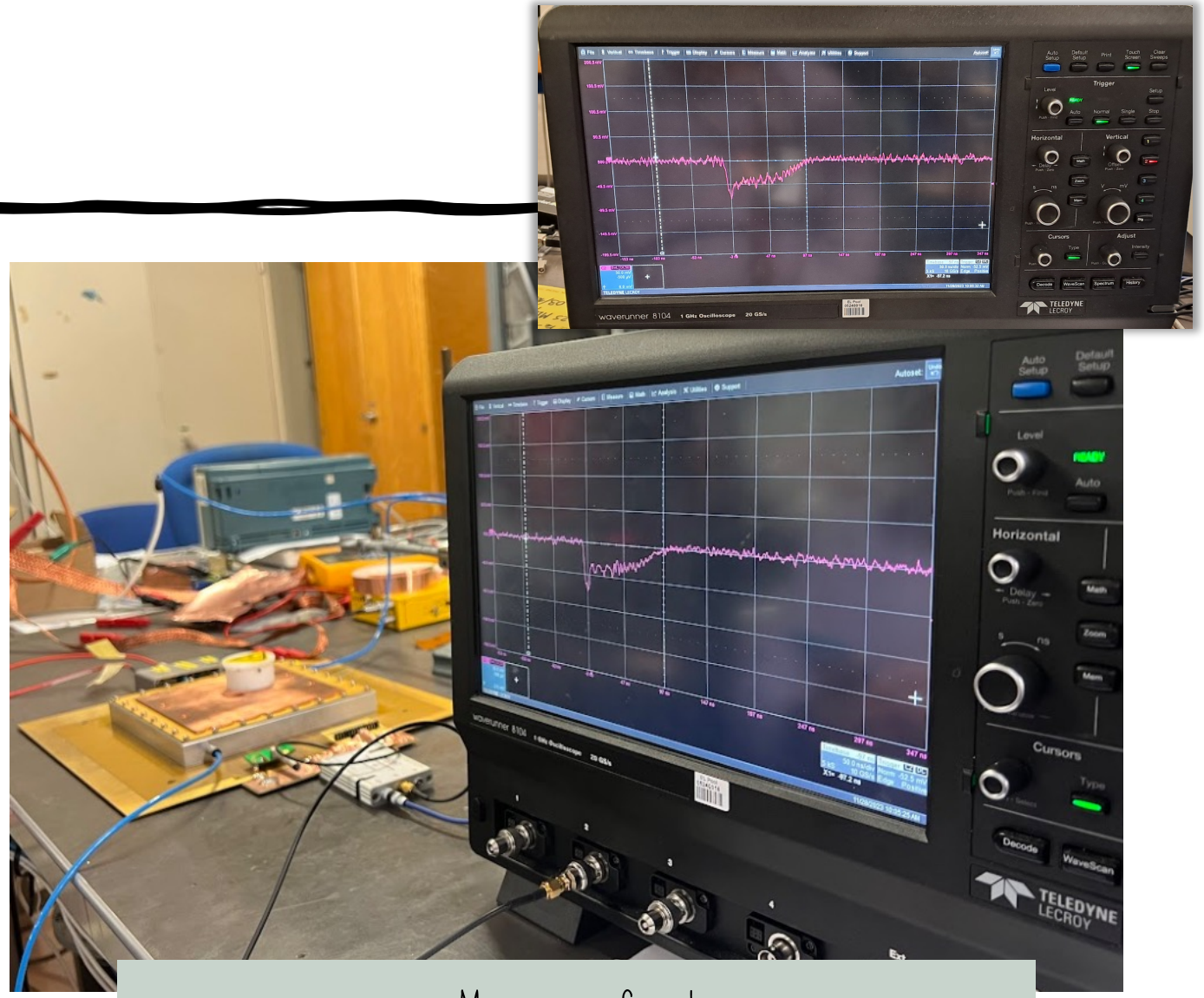


Background

Signal!

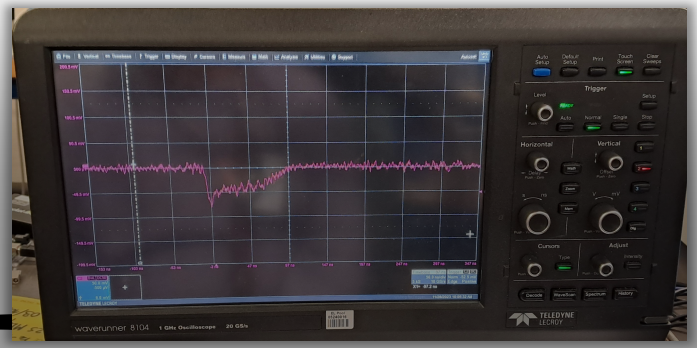


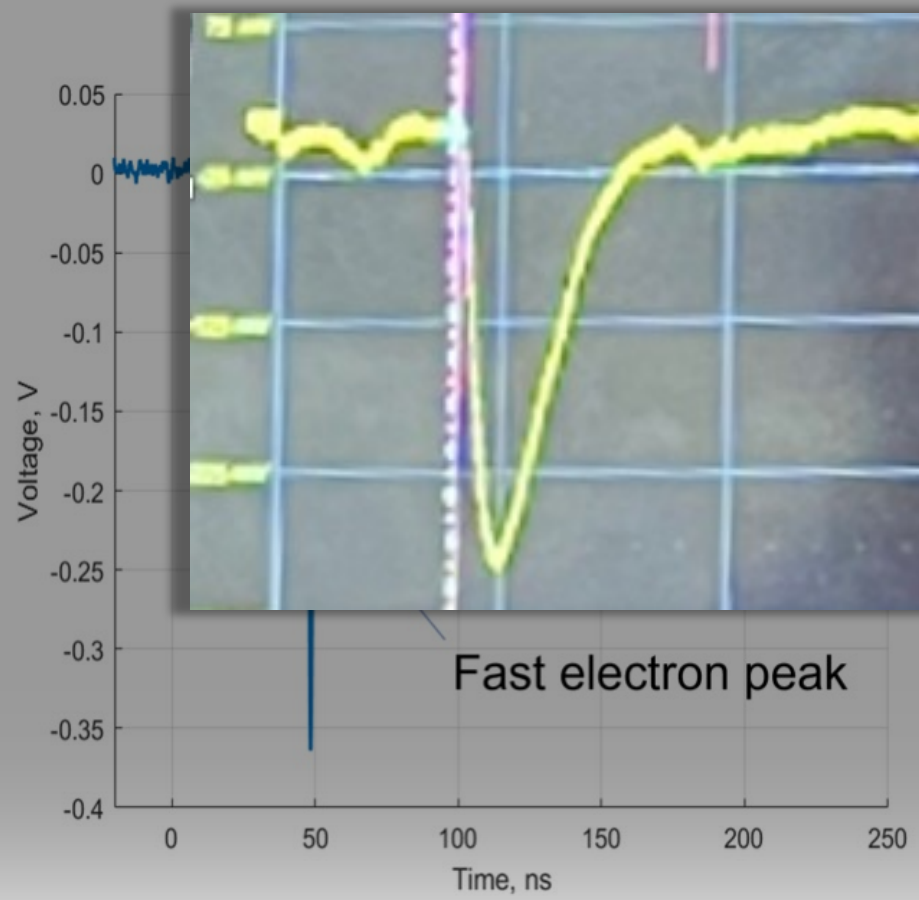
$u_{ion} = d_{conv}/t_{ion} = 0.05$ [cm/μs]



Micromegas Signal

Signal! 1 event!





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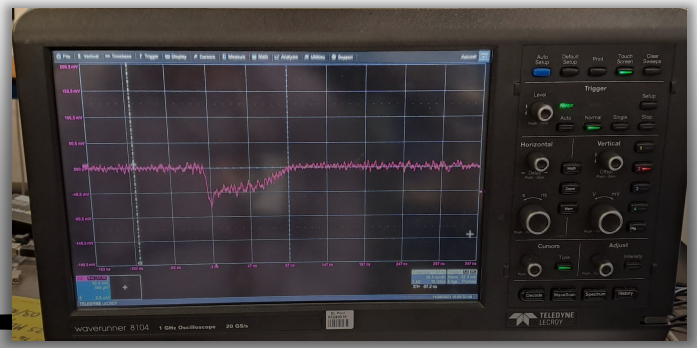
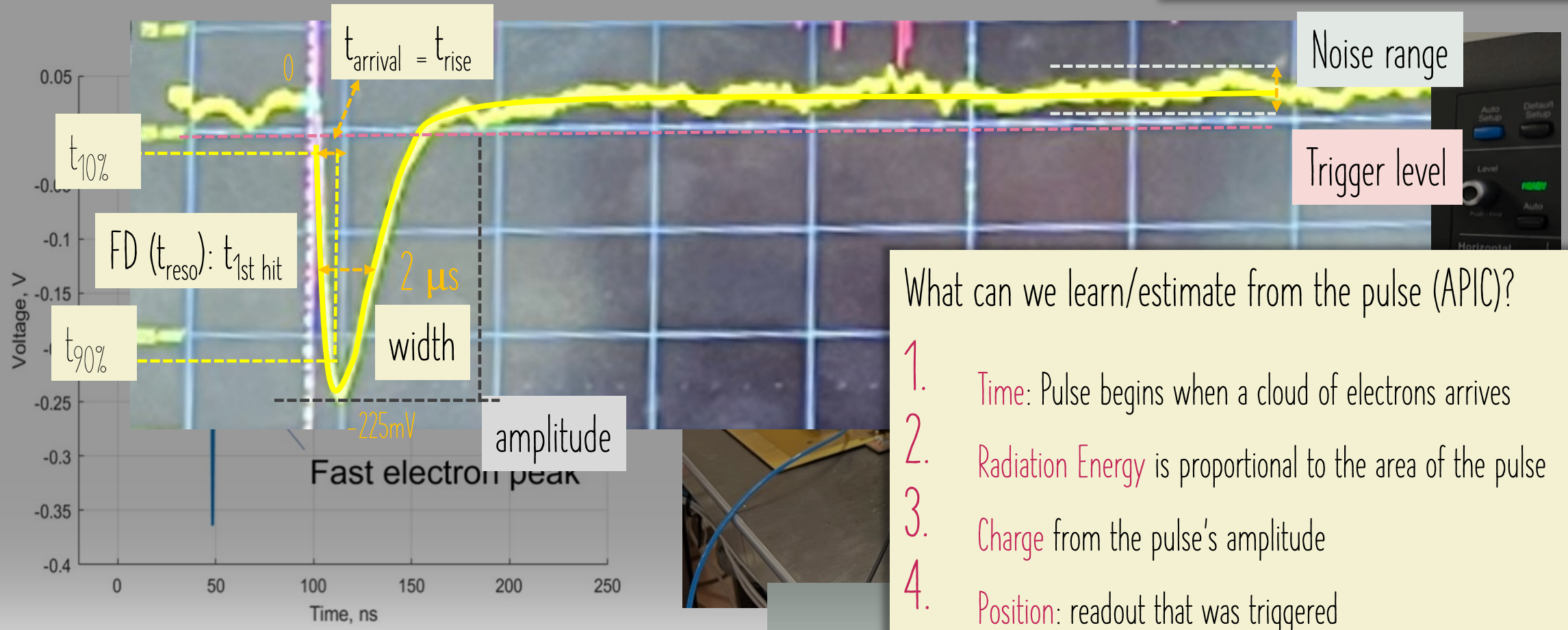


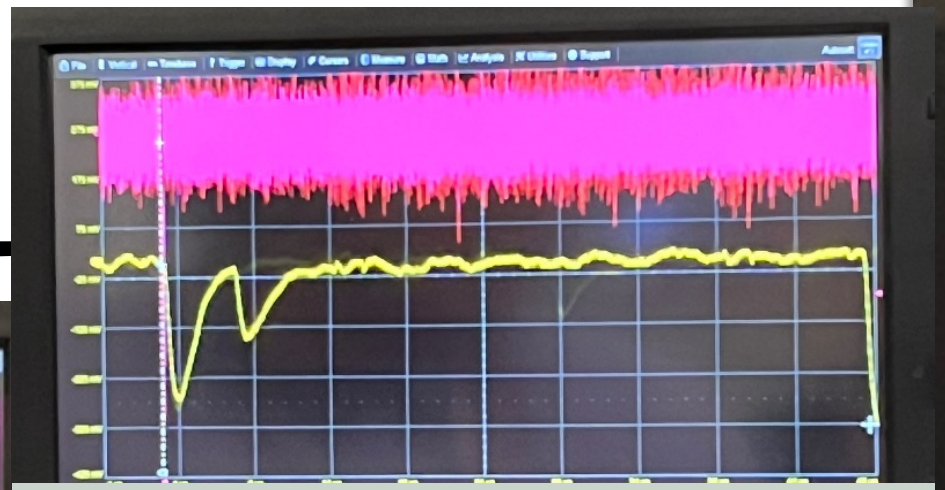


What can we learn/estimate from the pulse (APIC)?

1. Time: Pulse begins when a cloud of electrons arrives
2. Radiation Energy is proportional to the area of the pulse
3. Charge from the pulse's amplitude
4. Position: readout that was triggered

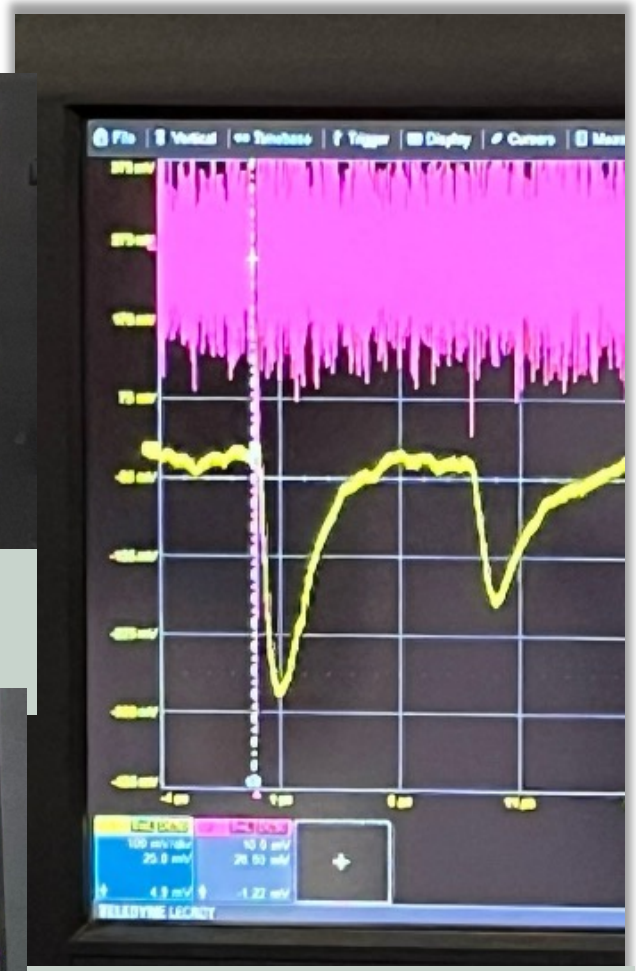
More instances!

Pileup: γ+Ar => Ar* + 2e-



Pileup event + Escape

Pileup events



Argon Escape Peak

Gain Calculation

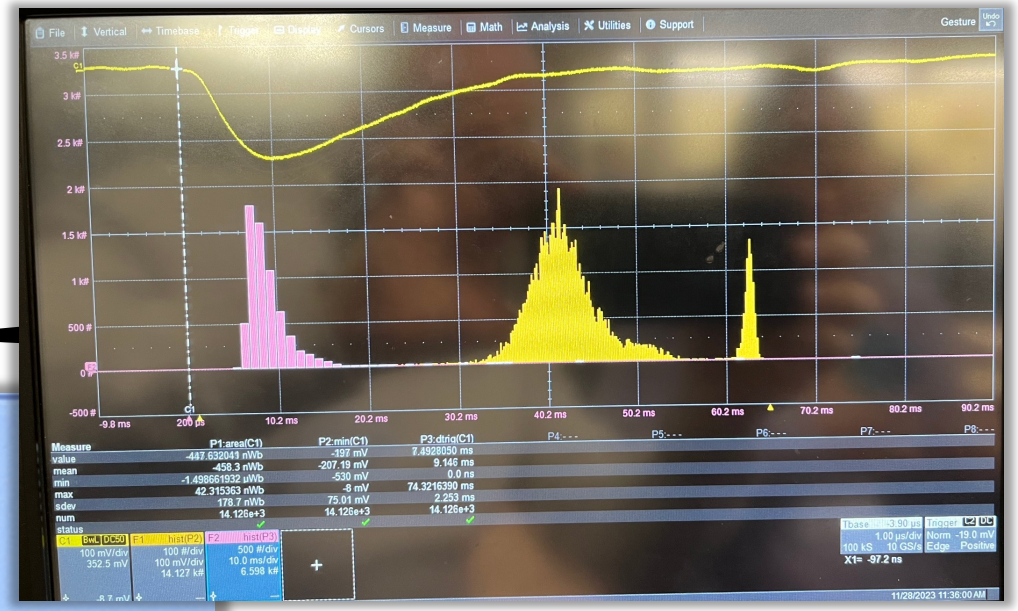
$$\text{GAIN} = \frac{I_{amp}}{I_{drift}} = \frac{\text{Current Measured Pulse}}{\#\text{of primary pairs} \times Q_{e^-} \times \text{Rate [Hz]}} = \frac{I_{source} - I_{dark}\,[nA]}{\#\text{of primary pairs} \times Q_{e^-}\,[C] \times \text{Rate [Hz]}}$$

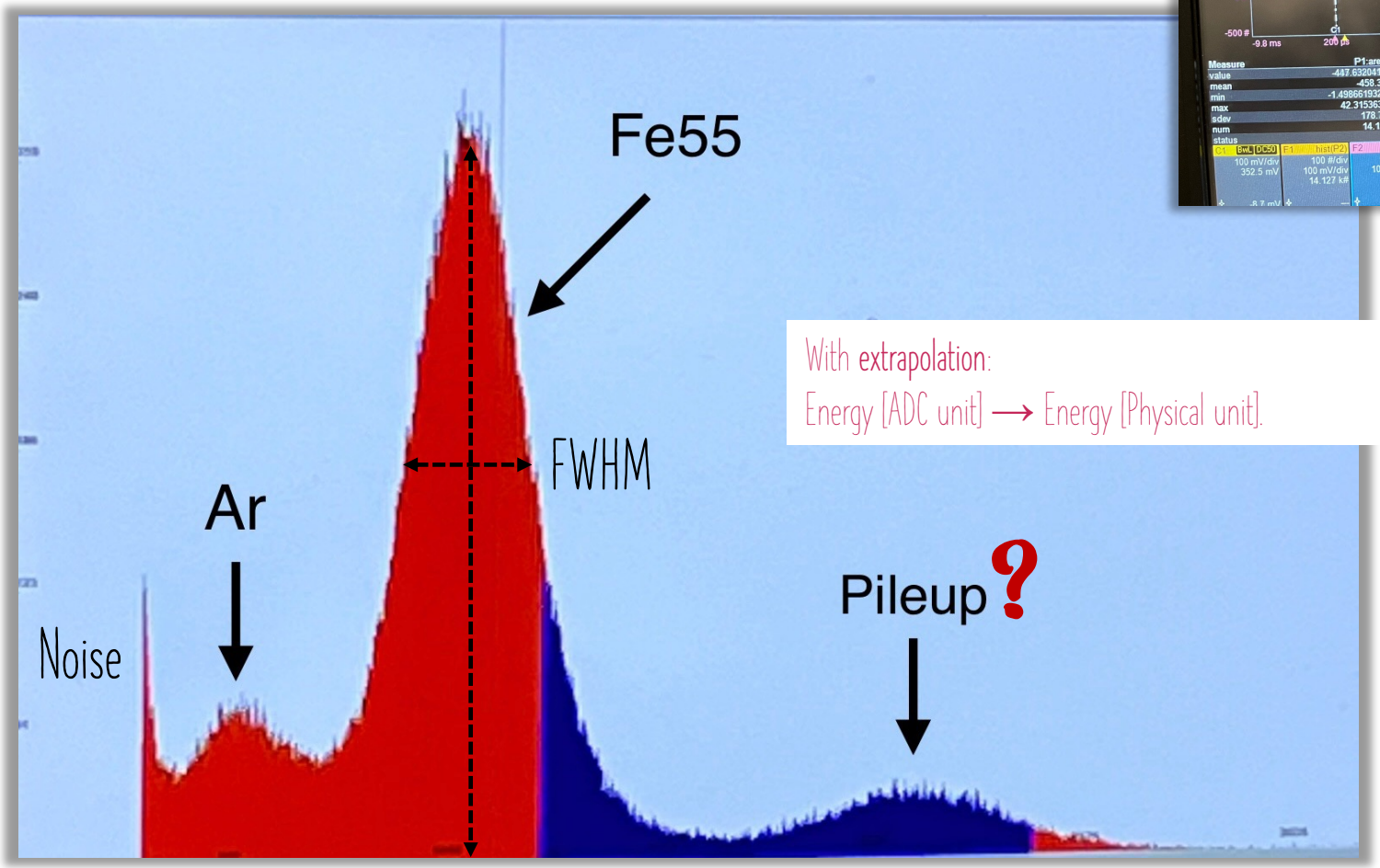
$$\#\text{of primary pairs} = \frac{\Delta E}{W_i} = \frac{5.9\ keV}{26.04\ eV} \xrightarrow{\text{weighted}} \frac{\Delta E(e^-)}{W_i}\,[85\%] + \frac{\Delta E(\text{escape})}{W_i}\,[15\%] = \boxed{210\ e^-}$$

$$W_i\,[Ar/CO2/iC4H10] = W_{Ar}\,[93\%] + W_{CO2}\,[5\%] + W_{iC4H10}\,[2\%] = 26eV \times 0.93 + 33\ eV \times 0.05 + 10.5eV \times 0.02 = \underline{26.04eV}$$

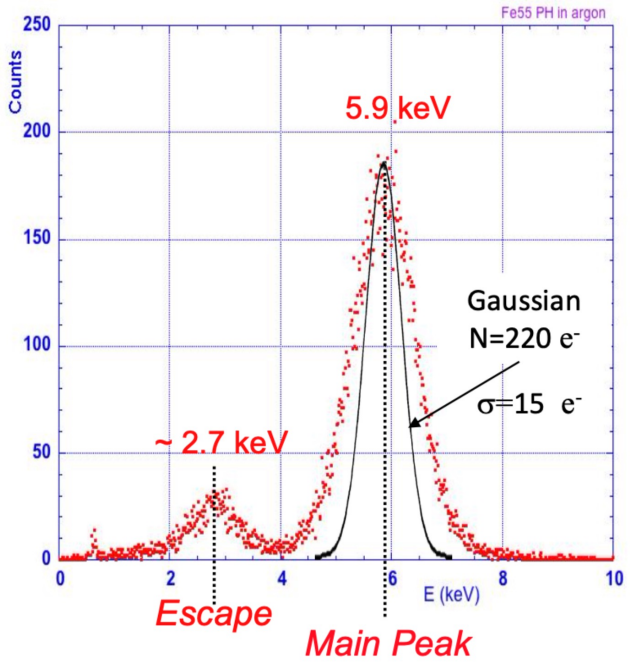
$$\text{GAIN}\Big|_{V(d,a)=(250,470)} = \frac{2.7}{210 \times 1.6 \times \mathbf{10^{-19}} \times 8561} = \boxed{9500}$$

ADC Spectrum

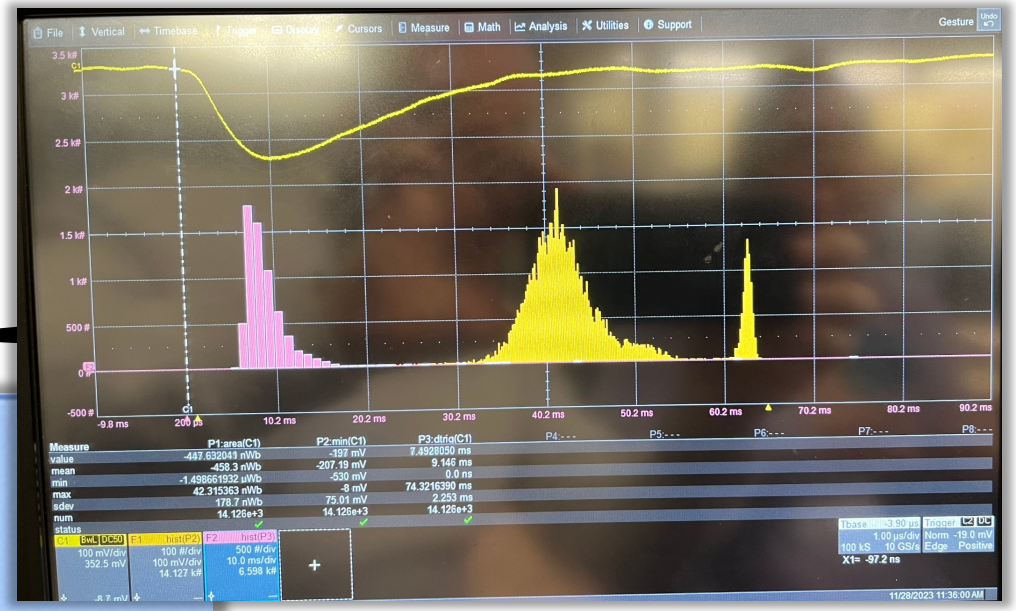


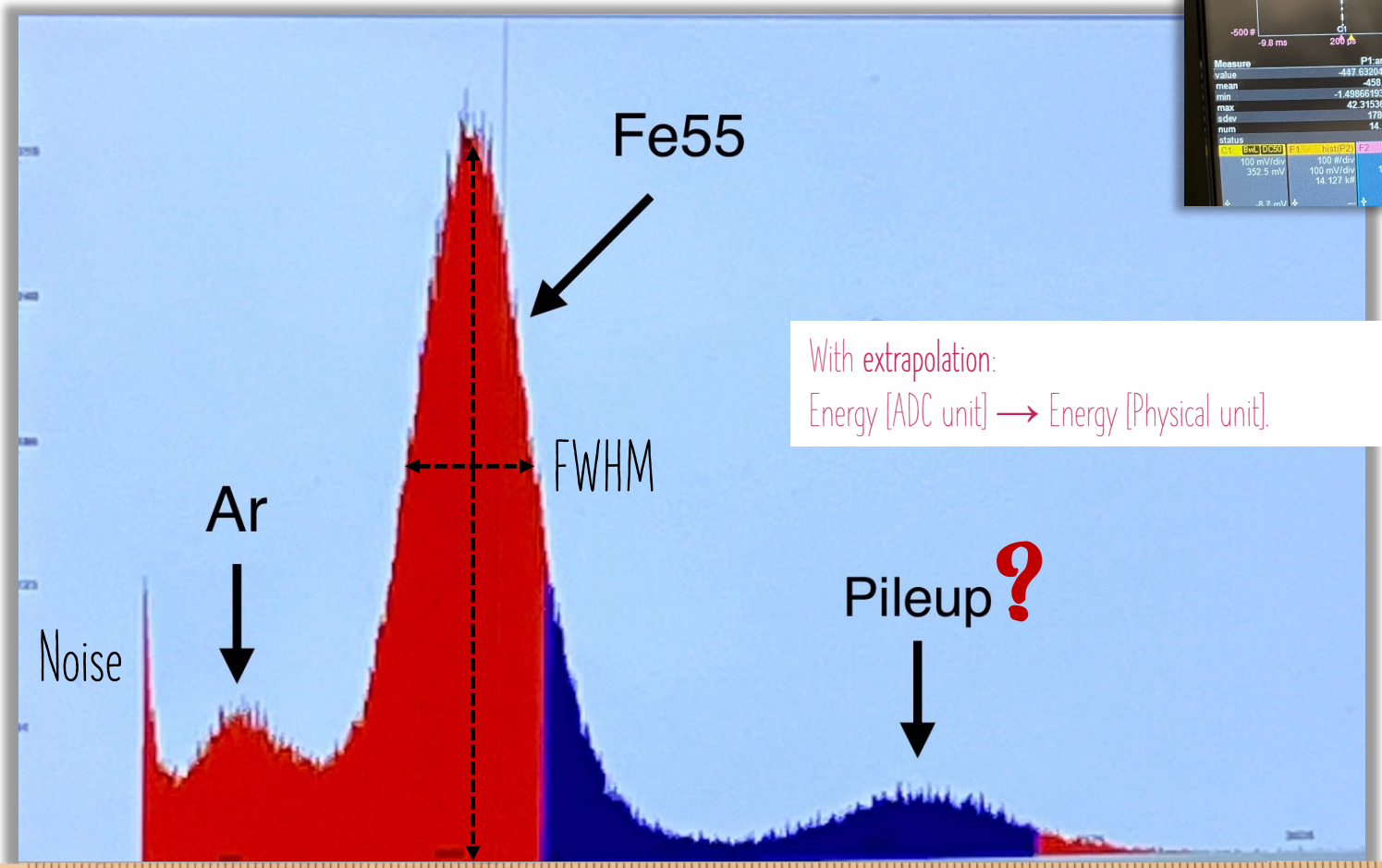


With extrapolation:
Energy [ADC unit] ⟶ Energy [Physical unit].



ADC Spectrum





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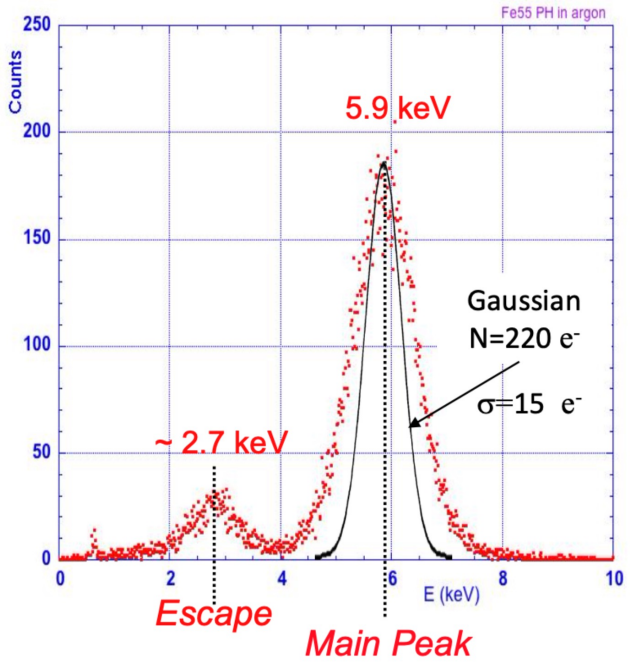
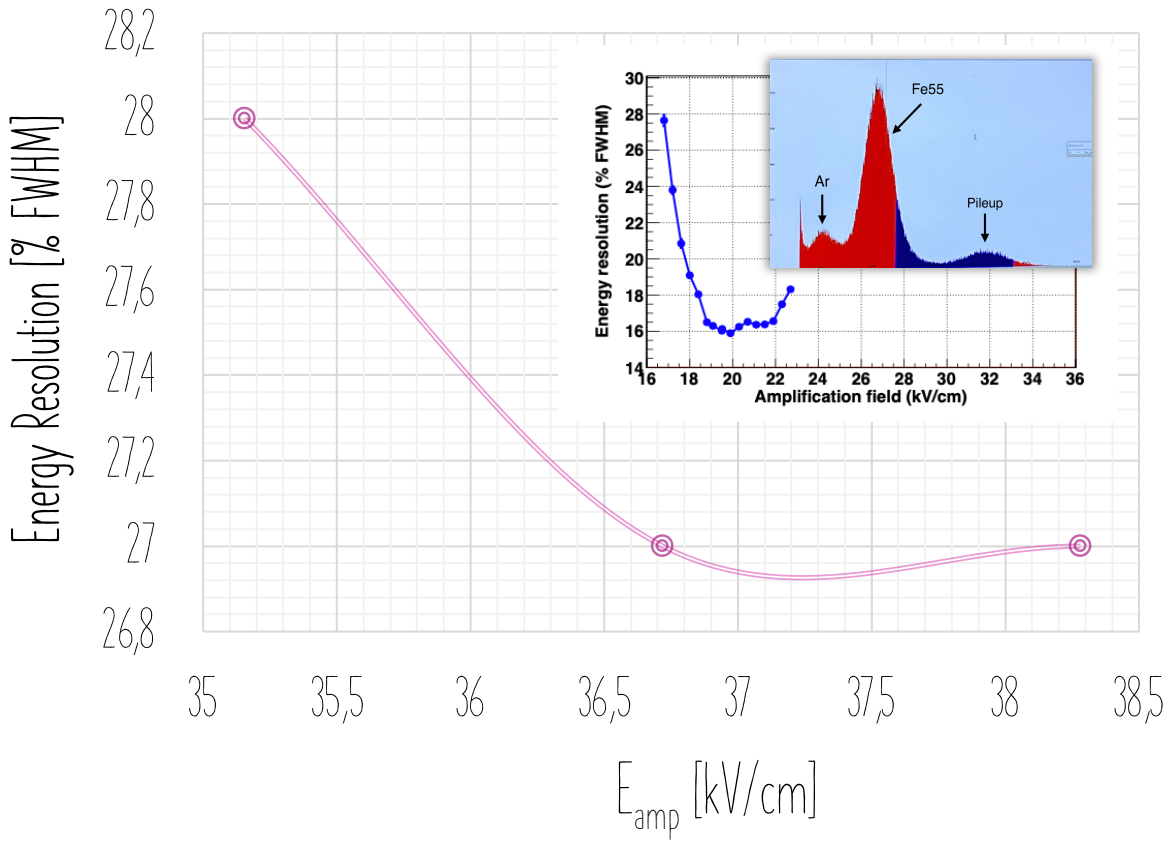


Energy Resolution

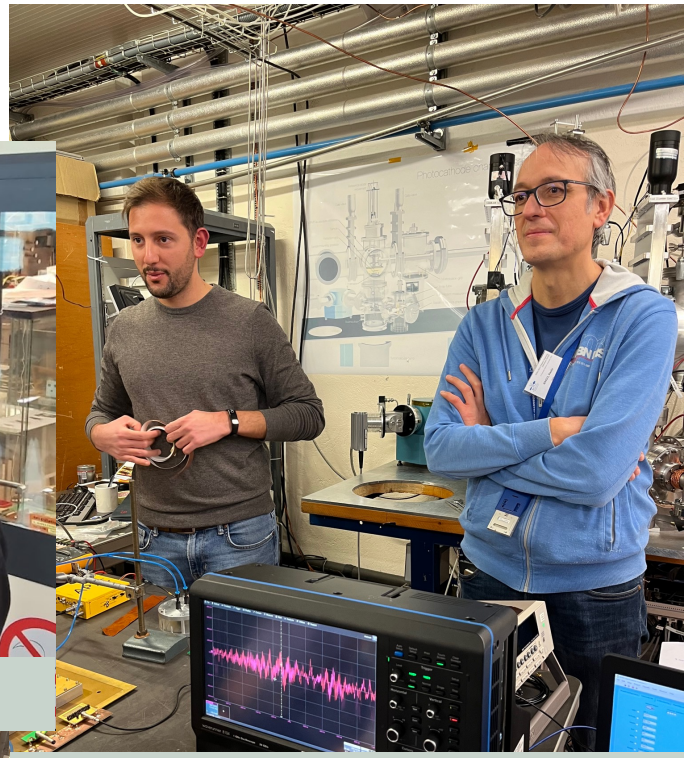
HV points (drift, strips)	(250,450)	(250,470)	(250,490)	(500,470)
Centroid [ADC counts]	1114.3	1042.3	897	2173
FWHM [fit]	312	281.7	257	594
Energy Resolution [%]	28	27	27	28
Eamp [kV/cm]	35.2	38, 3	36,7	36.72

$$\text{Energy resolution} = \frac{\text{FWHM}}{\text{Peak Centroid}}$$



Group 1: Remarks

Gas Detectors RD51 Lab



Tutors

Happily ever after!

Thank You!