SF_6 gas chamber calibration and ionization quenching factor measurements at COMIMAC facility

Direction-sensitive dark matter detection with gaseous tracking detectors

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FJPPL collaboration

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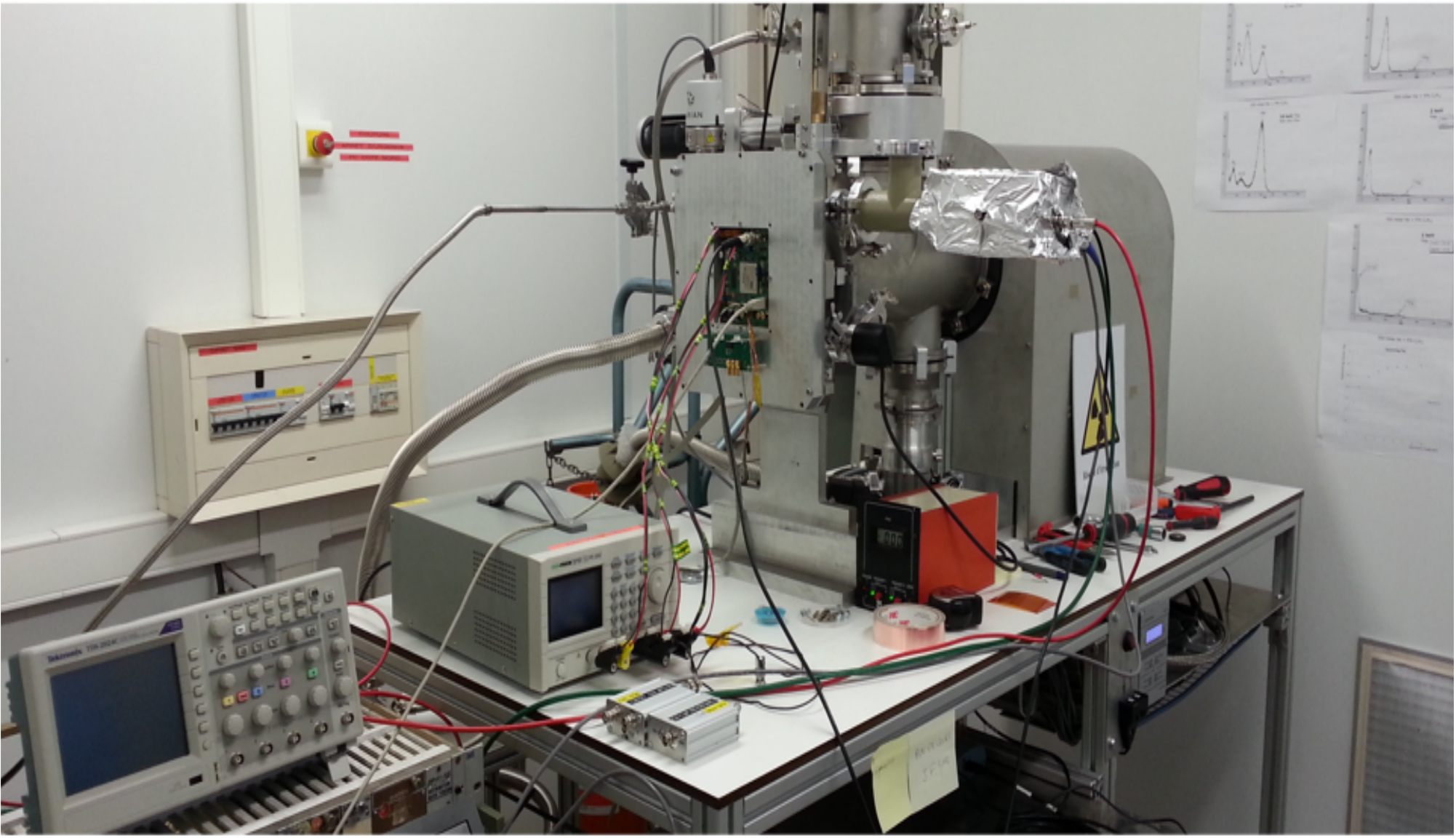
Experiment performed on December 2019 in Grenoble at the COMIMAC facility (LPSC)



Some of the important achievements obtained

i) We have sent electrons with a known kinetic energies (3, 5, 7 and 10 keV) into a SF_6 – MIMAC gas chamber at 30 mbar.

ii) In order to understand the physics of the electro-negative gas charge collection, we have used two different electronic read-outs (Kobe preamplifier and MIMAC preamplifier coupled to the MIMAC sampling strategy)

iii) The Kobe team performed Geant4 simulations for understanding the COMIMAC interface and the X-ray production on the interface at electron energies higher than 6.4 keV (iron X-rays)

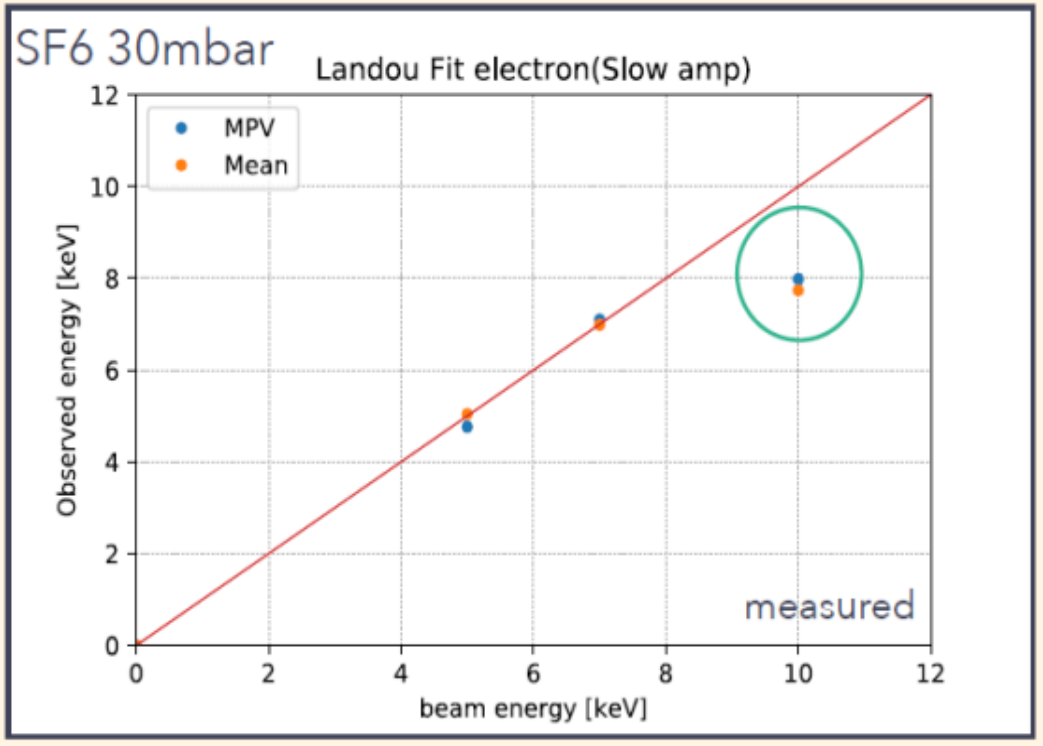
iv) We have got a preliminary linear calibration

v) We have sent ^{19}F of known kinetic energies and got the ionization signals. The data analysis of the quenching factor is in progress.

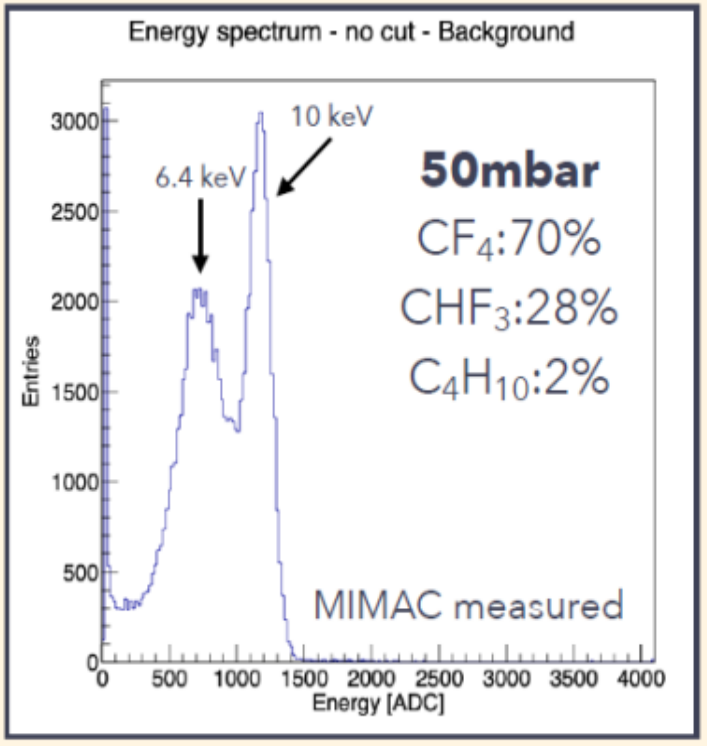
10 keV electron

- In the case of 10 keV electrons
  - 10 keV e- observed was lower than expected
  - electrons hitting the vessel (Fe) emit fluorescent X-rays -> 6.4 keV
  - we should consider X-ray effect
  - I checked X-ray effect with Geant4 simulation

Kobe slow amp electron plot (Landau Fit)

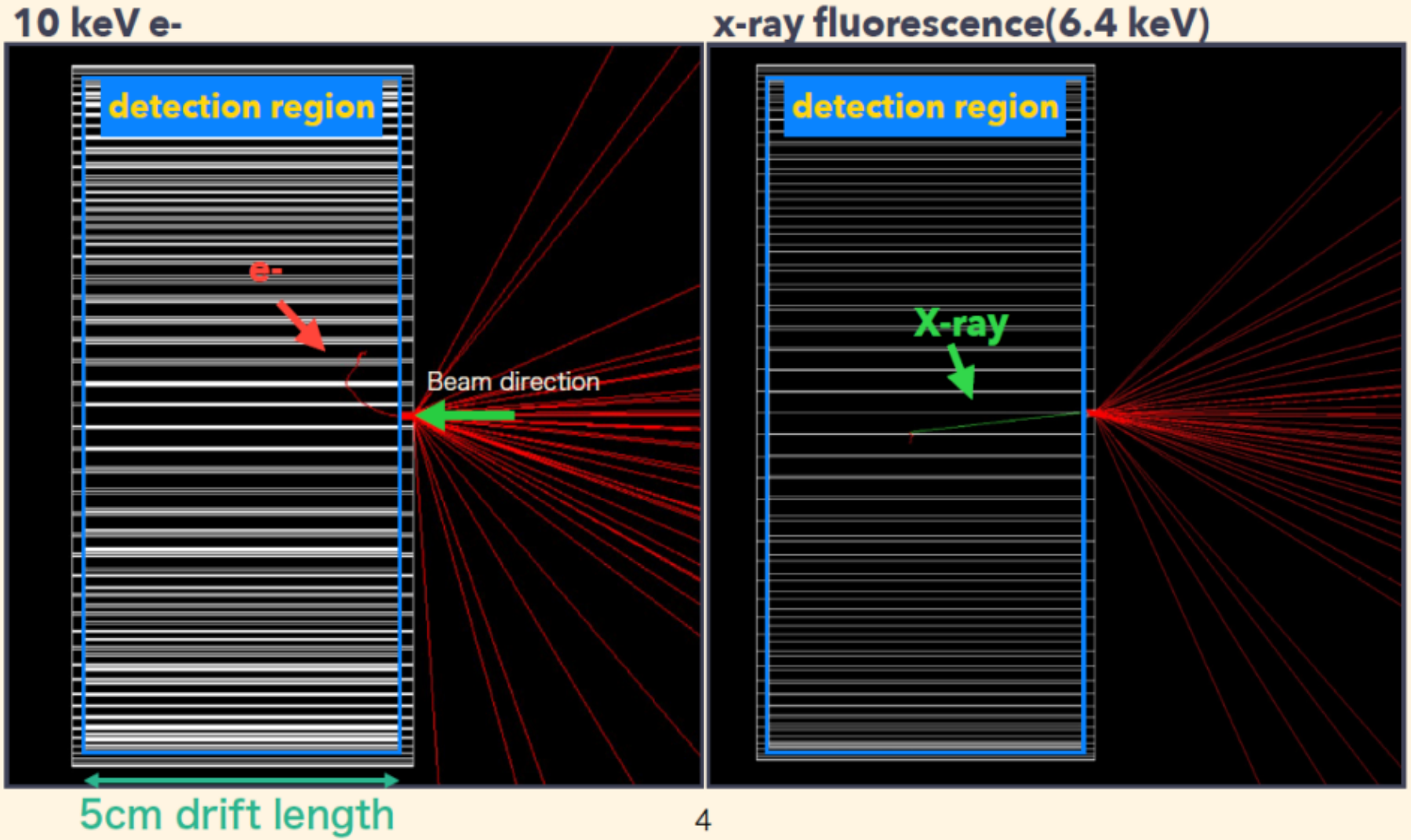


2020.03.04 Cyprien Slack elec10keV_MimacGas.root



Check x-ray (Geant4)

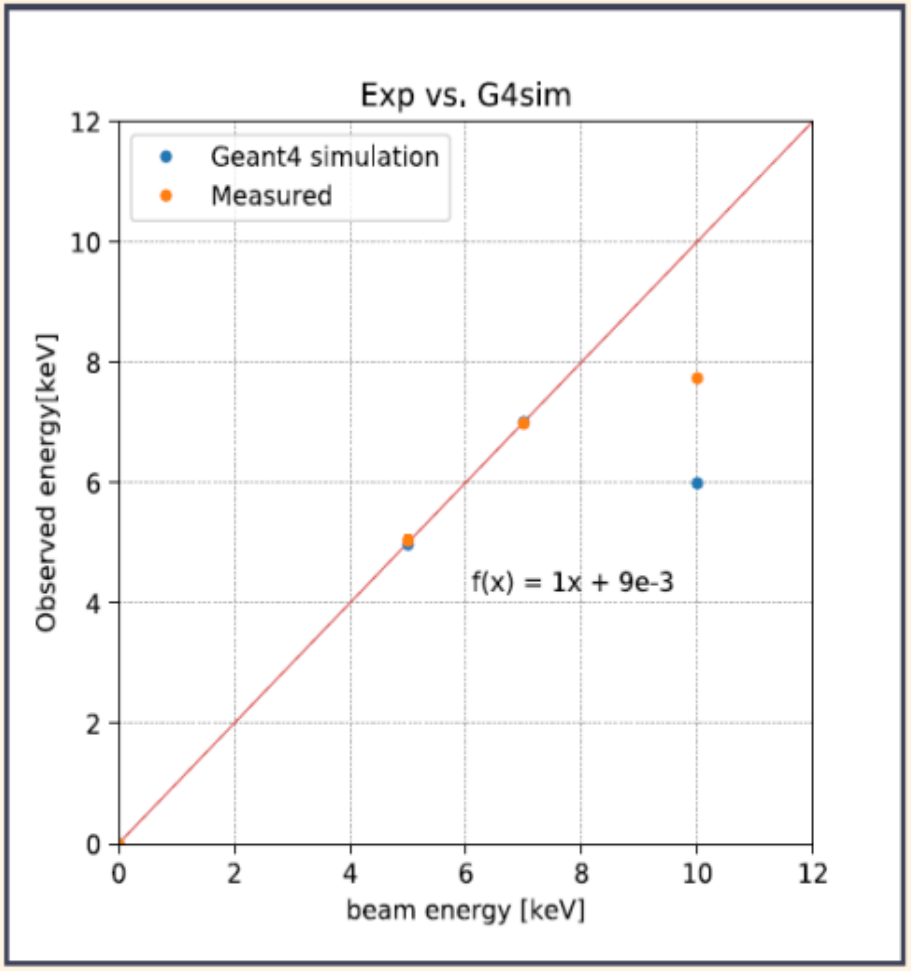
- I checked x-ray effect with Geant4 simulation
  - Electron original point : Φ1mm, from100μm, 0deg (beam hole=1μm)
  - Confirm x-ray emission



Experiment vs. Geant4 simulation

- Electron plot (Considering the effects of x-rays in Geant4)
  - The plot explain that 10 keV e- observed was lower than expected
  - It is difficult to observe 10 keV e- by x-ray

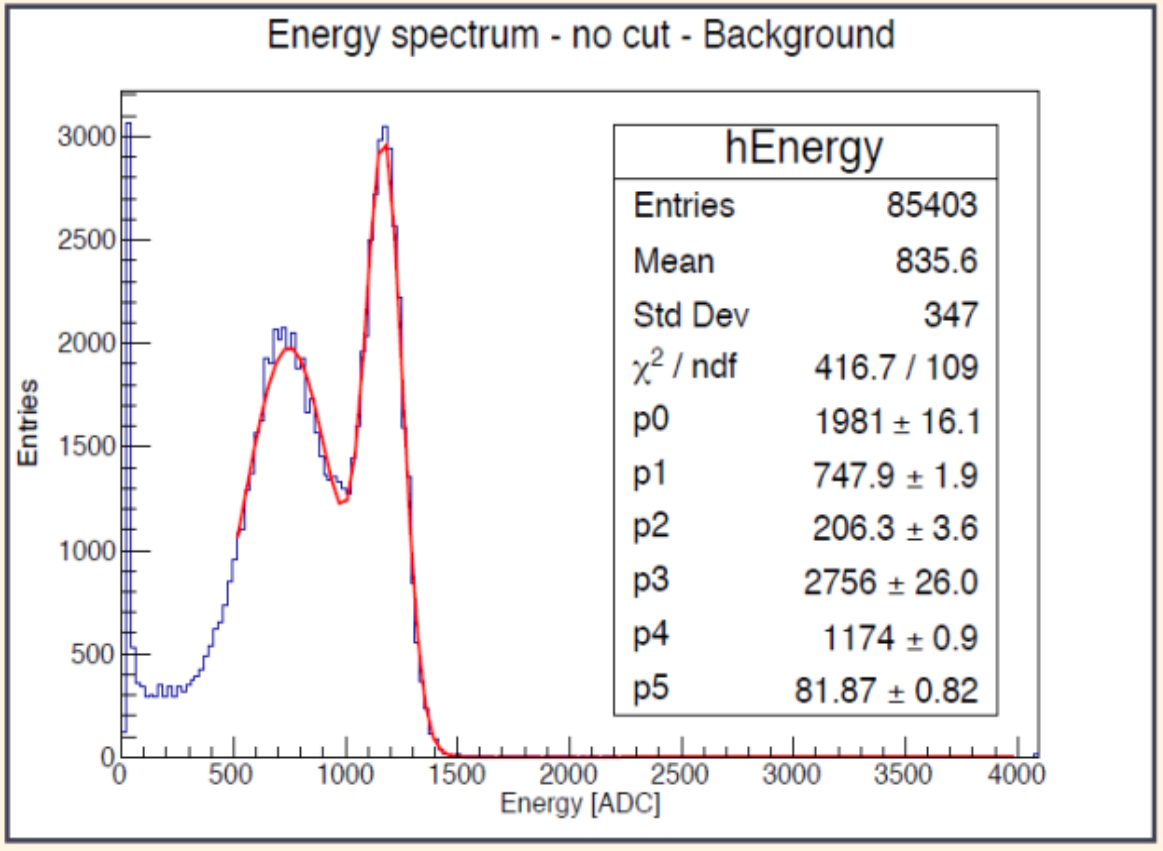
overcorrected



Ratio of 6.4 keV(x-ray) & 10 keV

- Estimate the ratio of 6.4 keV x-rays and 10 keV electrons using CF4 data
  - Fit func : Double gaussian
    - 6.4 keV (p0 : constant, p1 : mean, p2 : sigma)
    - 10 keV (p3 : constant, p4 : mean, p5 : sigma)
  - 6.4 keV : 10 keV = 1542 : 961 ~ **8 : 5**

MIMAC measured



50mbar

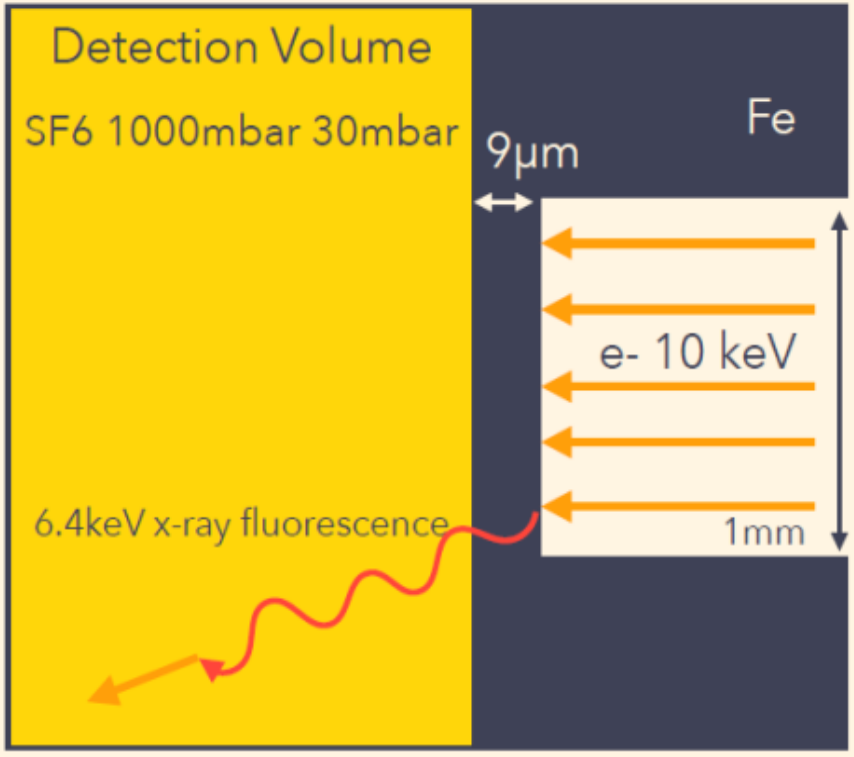
CF_4:70%

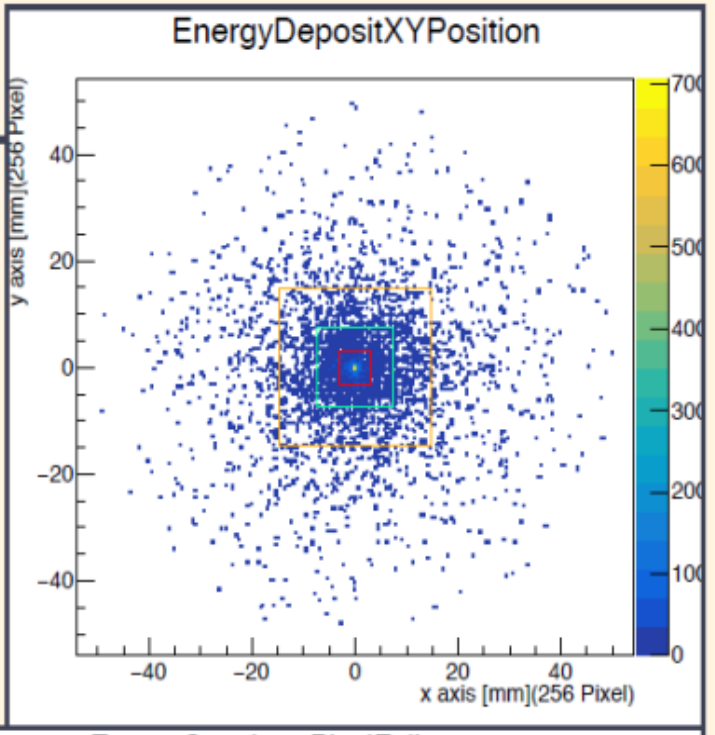
CHF_3:28%

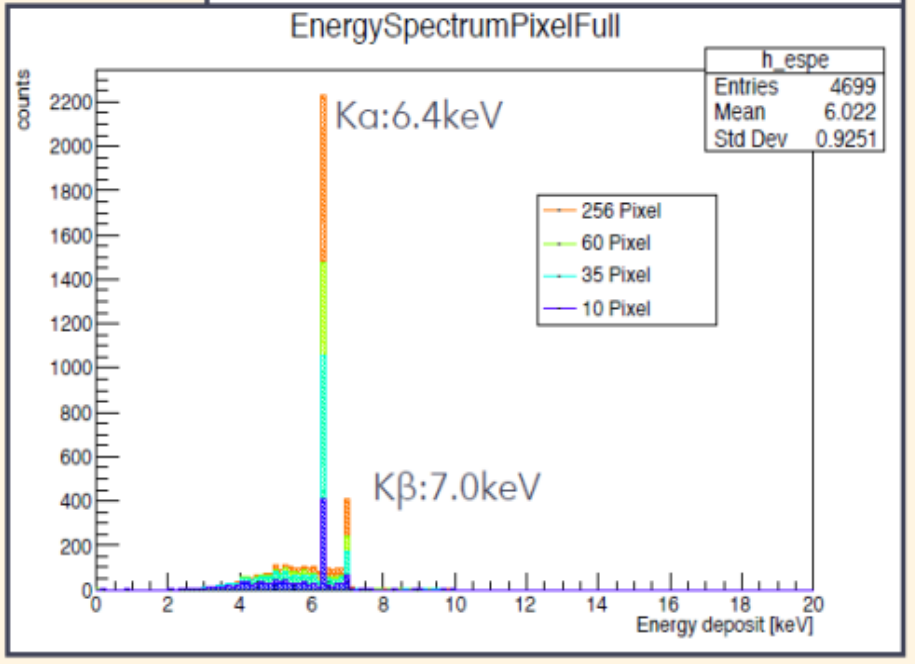
C_4H_{10}:2%

Check x-ray (Geant4)

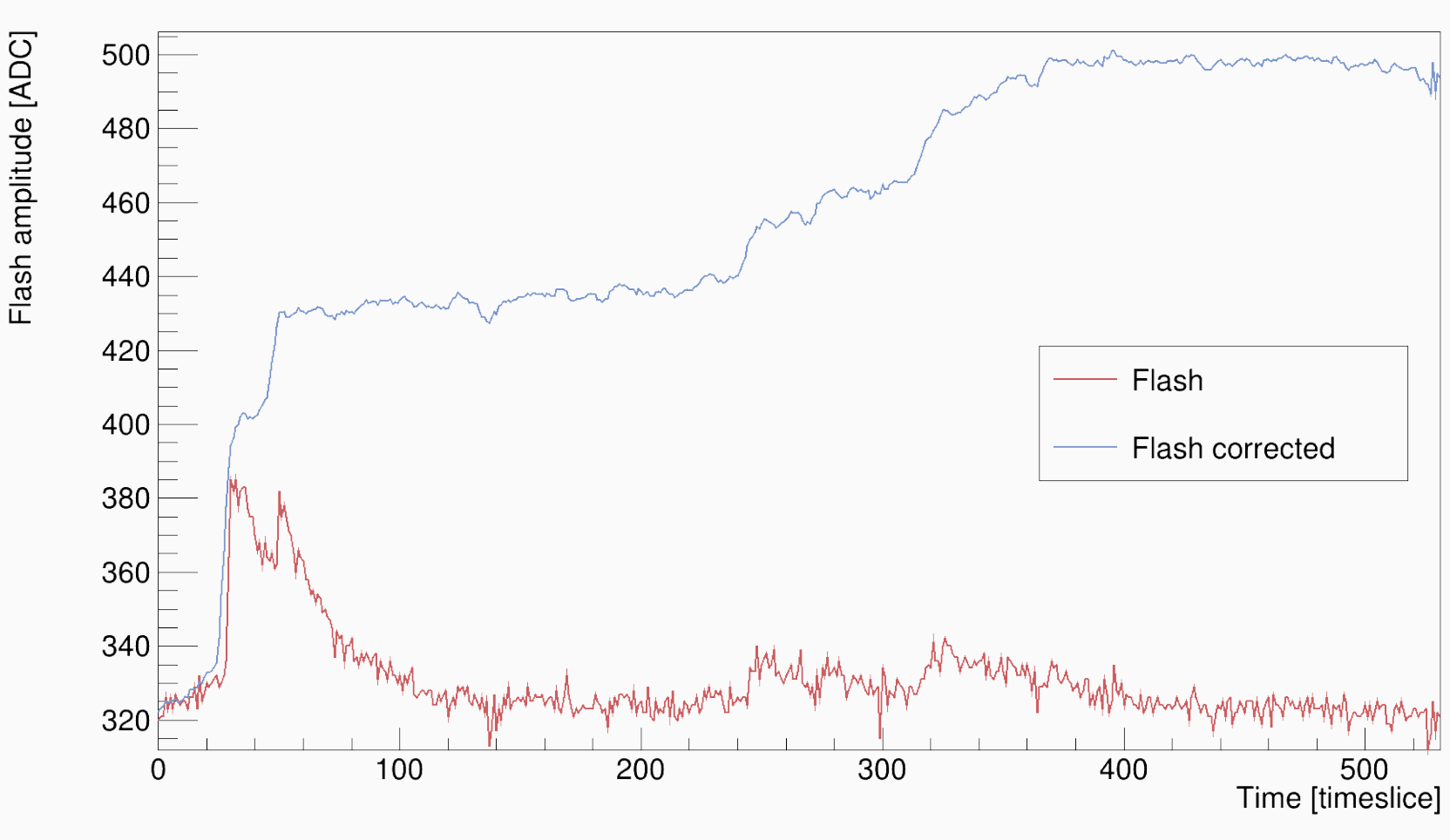
- Stat
  - e- 10 keV 10^8 events
  - SF6 1000mbar
- Confirm K_α and K_β of Fe







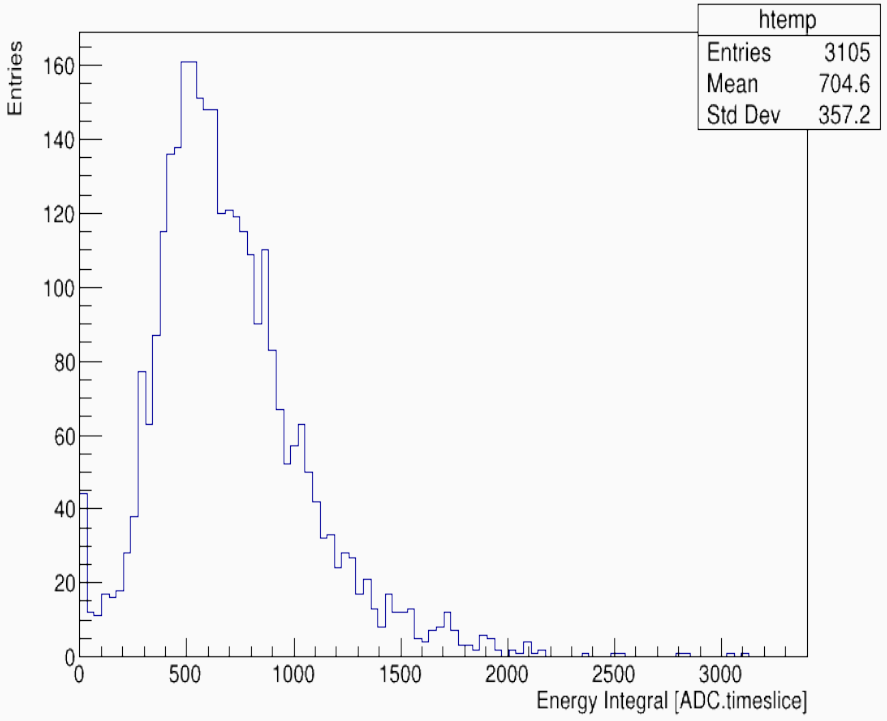
Flask ADC- Deconvolution



Deconvolution example - sampling 500ns

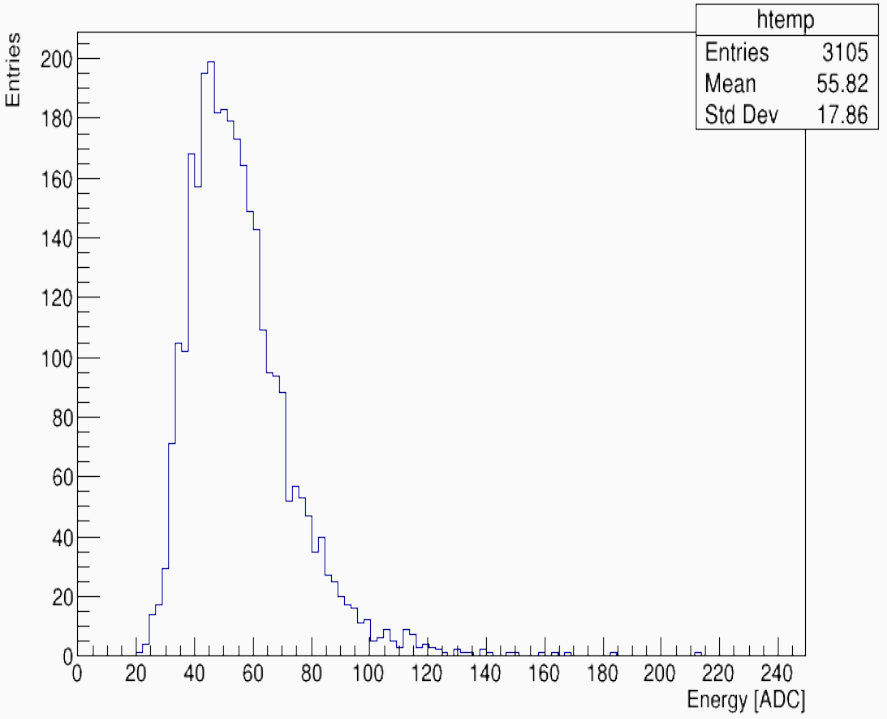
Comparison with previous method

Fluorine 10 keV : (-680V)



- Before correction-

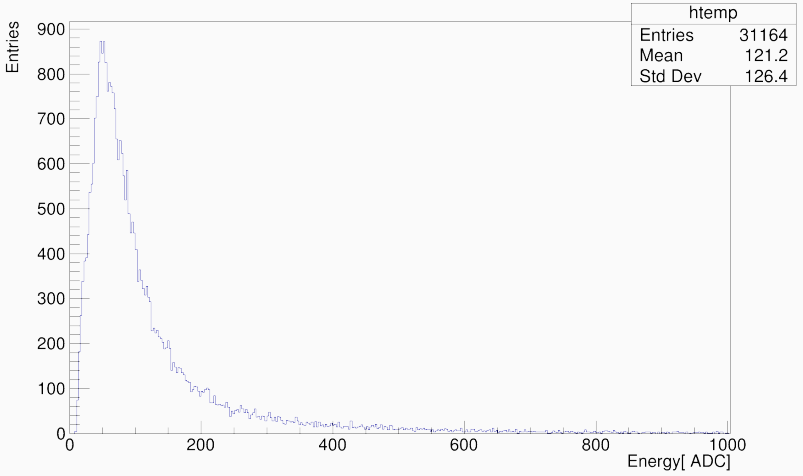
$\frac{\Delta E}{E}$ ~ 50%



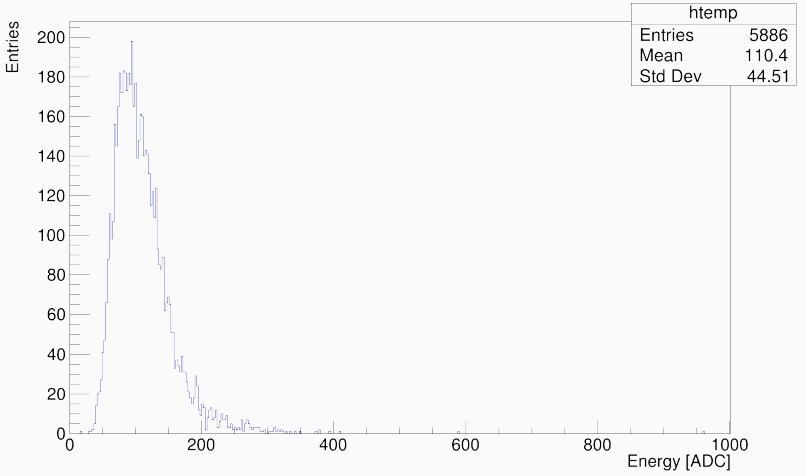
- After correction -

$\frac{\Delta E}{E}$ ~ 30%

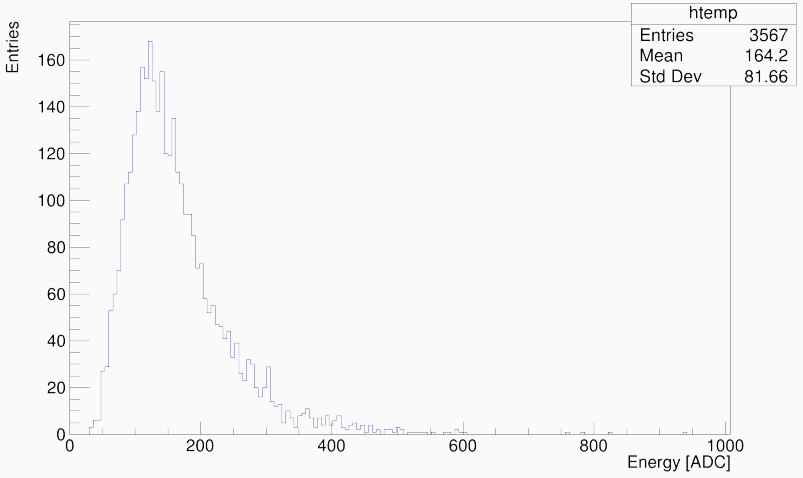
Electron measurements



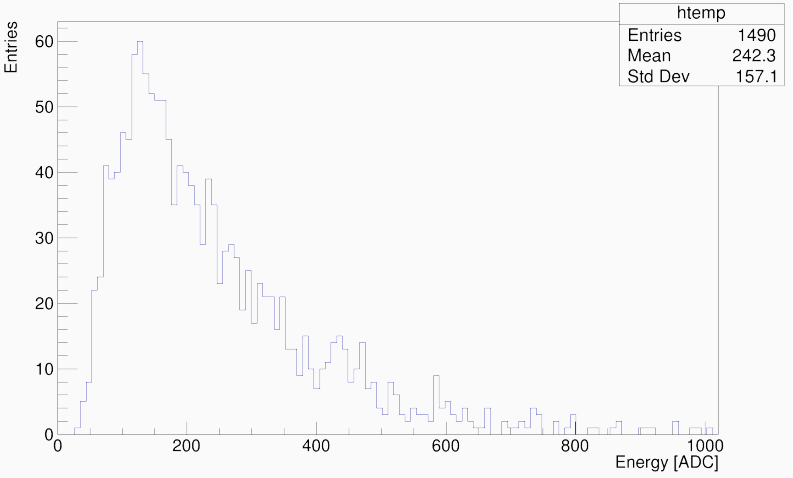
3keV



5keV



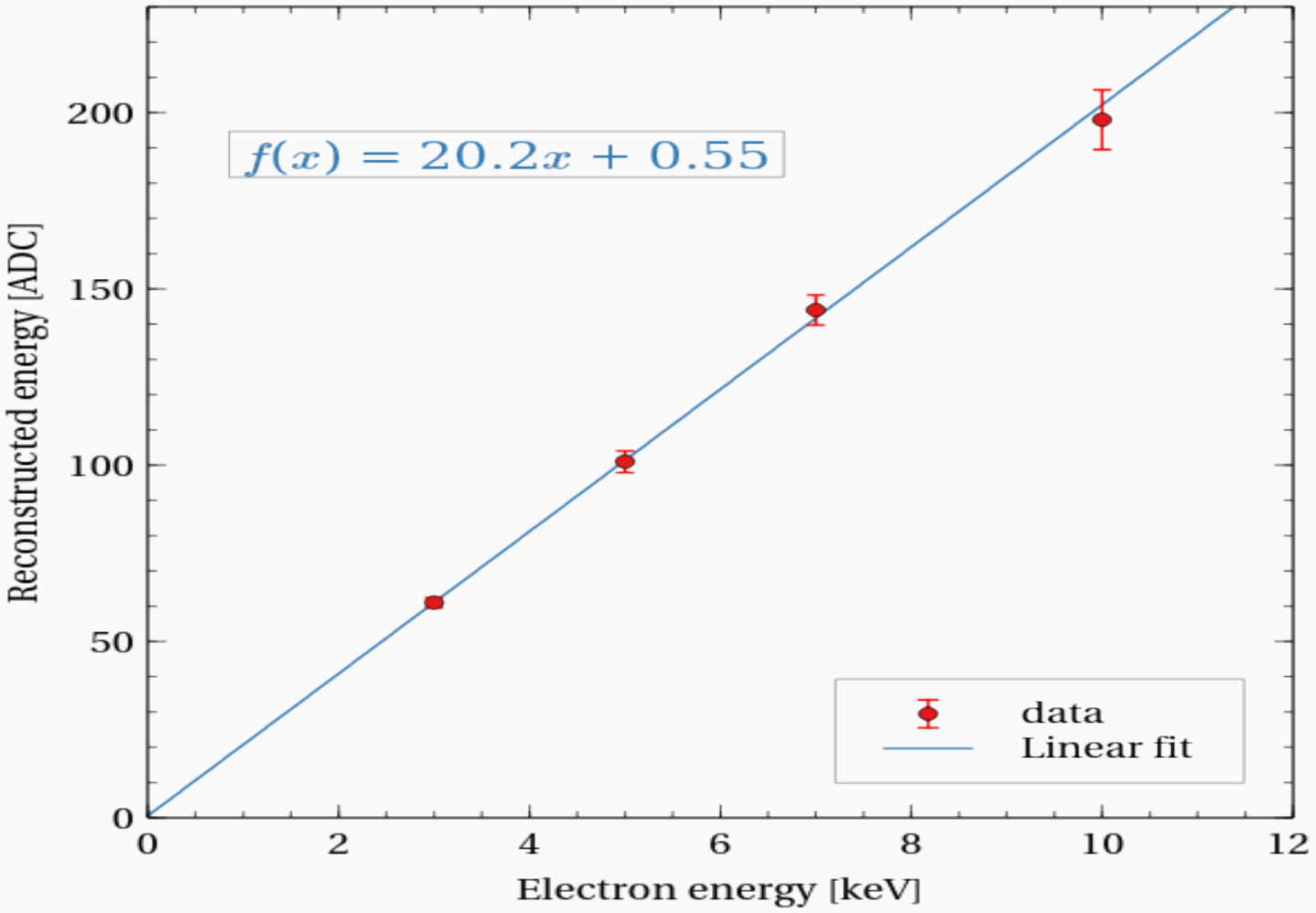
7keV



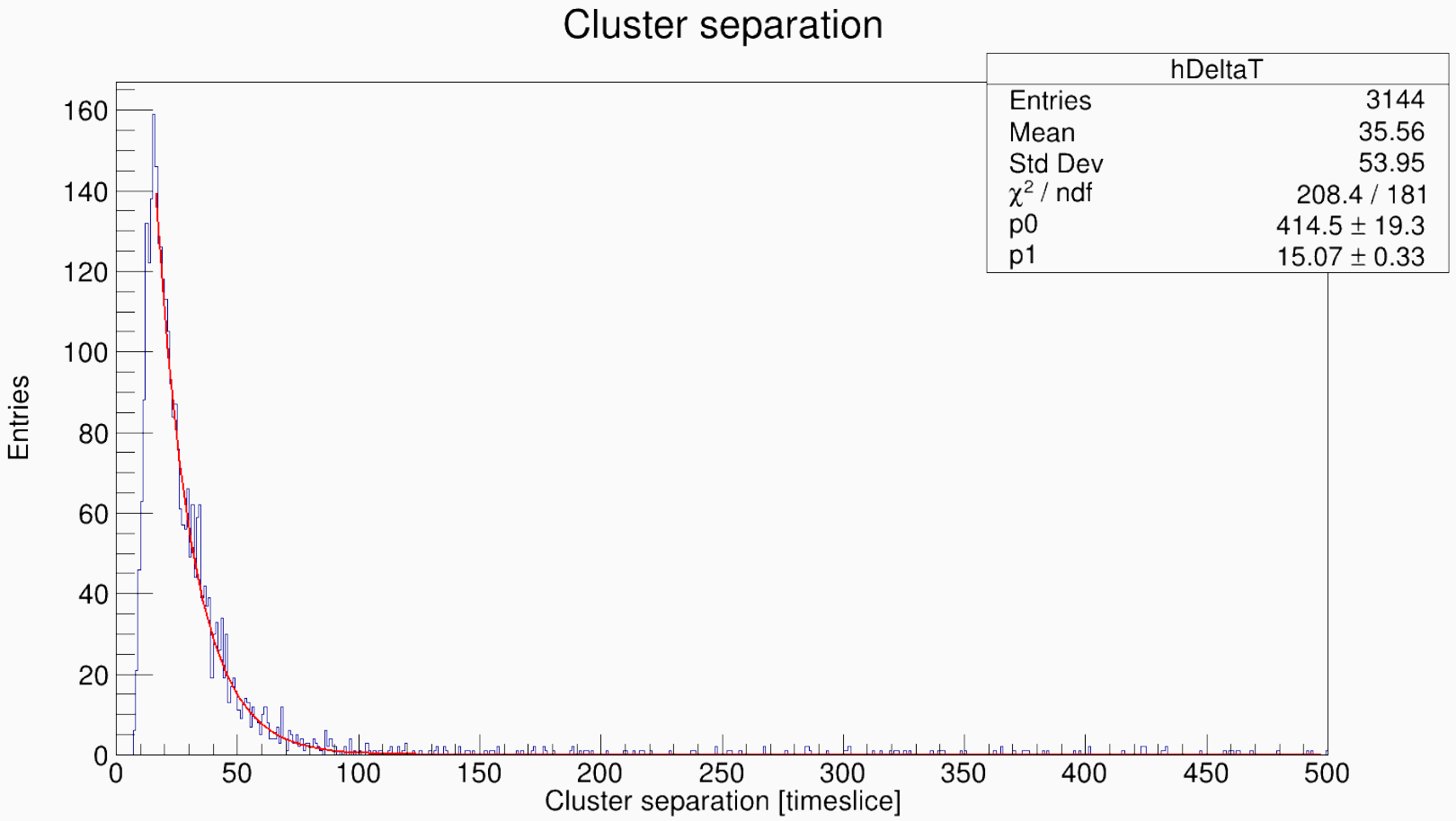
10keV

Calibration (preliminary results)

Setup : -680V ; sampling 2μs ; error bars 3σ (corrected from previous presentation)



Time between Flash ADC clusters



Electron 10keV - Sampling 2μs - $V_{grid} = -680V$

Process half-time $\tau \sim 30\mu s$

Summary and Next steps

- The FADC-signal contains multiple contributions due to the SF_6^- auto-detachment
- The deconvolution of the preamplifier response function increases the resolution
- We are working on a model of the charge collection in the SF_6
- Linear electron calibration between 3 – 10 keV (a paper is in progress)

Next steps :

- Signal smoothing
- Fluorine analysis
- Simulation and data analysis of the auto-detachment process
- New experiments validating the hypothesis and calculations using different drift distances.