Study of gas gain fluctuations

Contribution to WG2 activity within RD51

Common characterisation and physics issues

Overview

Motivations
Investigation methods / Measurement of gain variance
Experimental setup at LAPP

Study proposal:
http://lappweb.in2p3.fr/~chefdevi/Work_LAPP/Gain_flucutations/

Motivations

- Final avalanche size obeys a probability distribution
  Signal fluctuations impact on detector performance
  - Spatial resolution in a TPC
  - Energy resolution in amplification-based gas detectors
  - Minimum gain and ion backflow
  - Detection of single electrons with a pixel chip

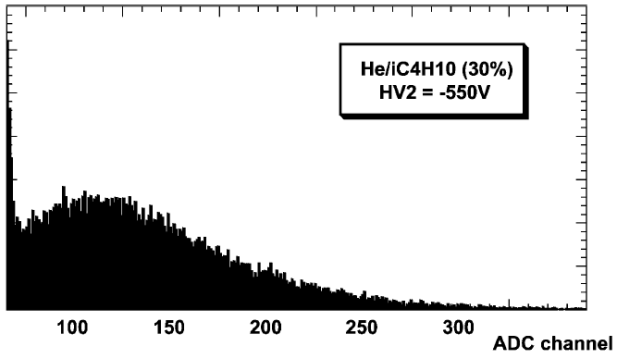
- What is the shape of the distribution?
  How does it vary with gas, field, geometry…?

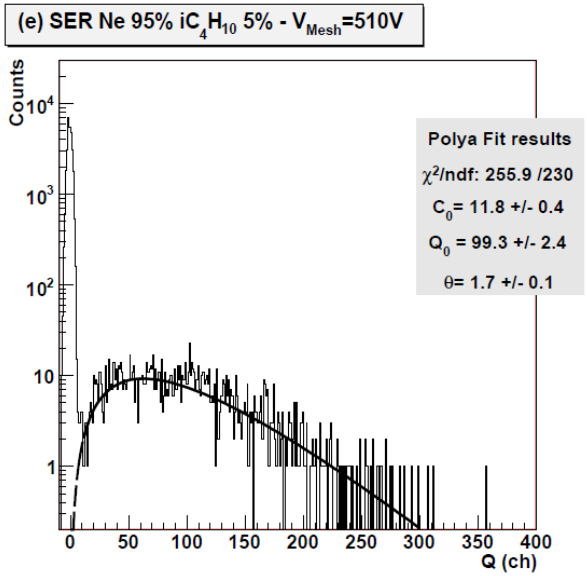
- The Polya distribution parametrized by
  gas gain *G* and parameter *m*
  - Works well with Micromegas/PPC/MCP/single GEM
  - With GEM stacks, distribution is more exponential

$$p_m(g) = \frac{m^m}{\Gamma(m)} \frac{1}{G} \left(\frac{g}{G}\right)^{m-1} \exp(-mg/G)$$

$\sigma^2 = 1/m$ = *b, relative gain variance*

Micromegas, NIMA 461 (2001) 84

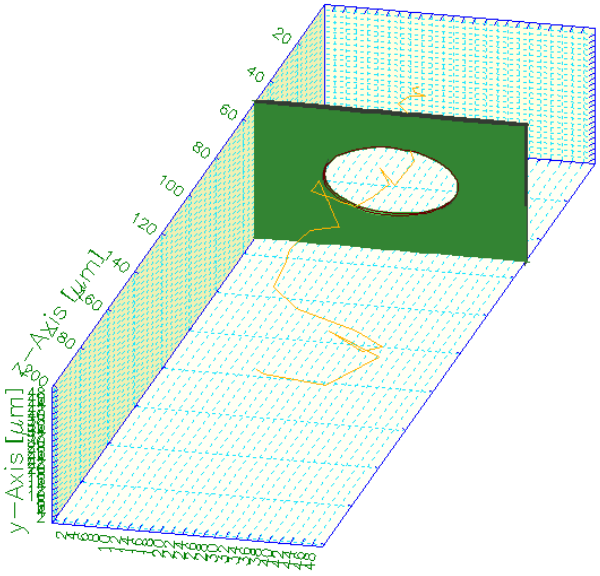




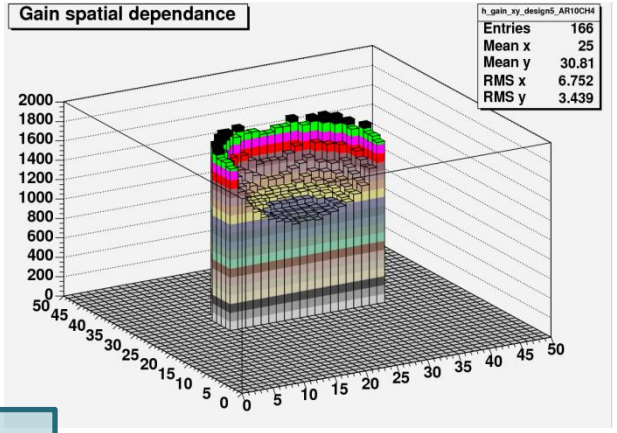
Micromegas
T. Zerguerras et al.
to be published in NIMA

Investigation methods

- **Simulation, since recently within GARFIELD:**
  - Simulation of e- avalanche according to MAGBOLTZ cross-section database:
    study of gas & field
  - Simulation of e- tracking at microscopic scale in field maps (3D):
    study of geometry



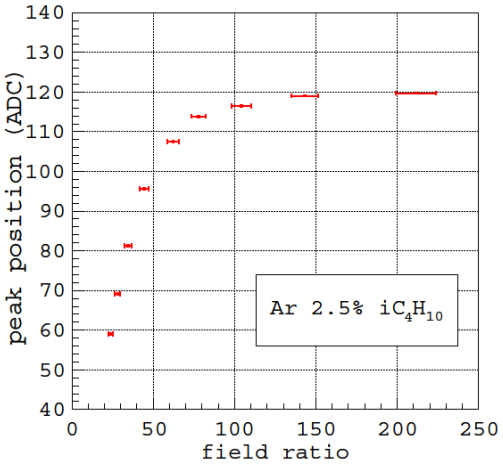
- **On the experimental side:**
  - Direct measurement of the distribution:
    - High gains, low noise electronics, single electron source
  - Indirect measurements
    - Do not provide the shape but some moments (variance)
    - Assuming Polya-like fluctuations, one obtains the shape



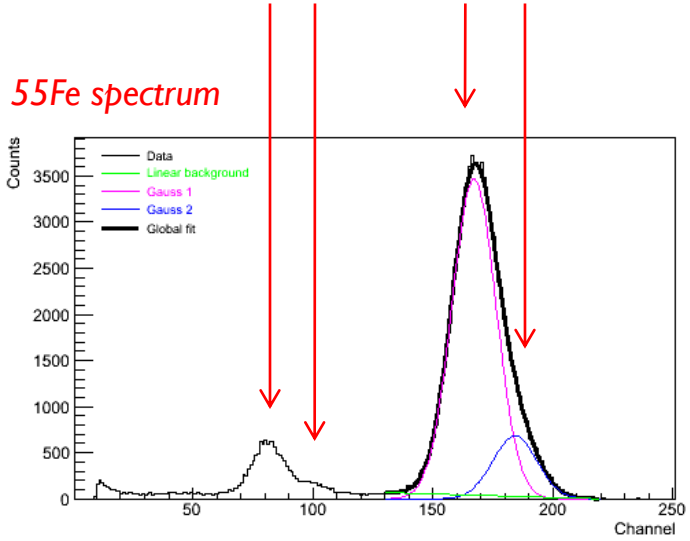
- In this talk, only indirect methods are presented
  The Polya parameter *m* is deduced from:
  - Trend of energy resolution and collection efficiency
  - Trend of single electron detection efficiency and gas gain

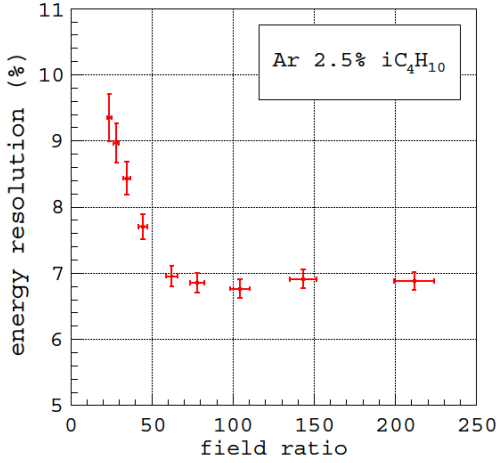
Measurement of gain variance with 55Fe

- **Energy resolution *R* depends on Fano factor, gain variance, number of primary electron and electron collection efficiency *η***
  - $R^2 = F/N + b/\eta N + (1-\eta)/\eta N$
  - **Measure *R(η)* at e.g. 5.9 keV**
    Fix *F* and *N*, adjust *b* (i.e. *m*) on data
  - **Measure *R(N)* at various energy with *η* = 1**
    Fix *F*, adjust *b*



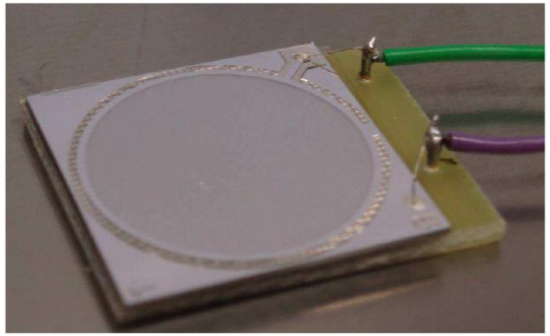
4 main lines in an 55Fe spectrum

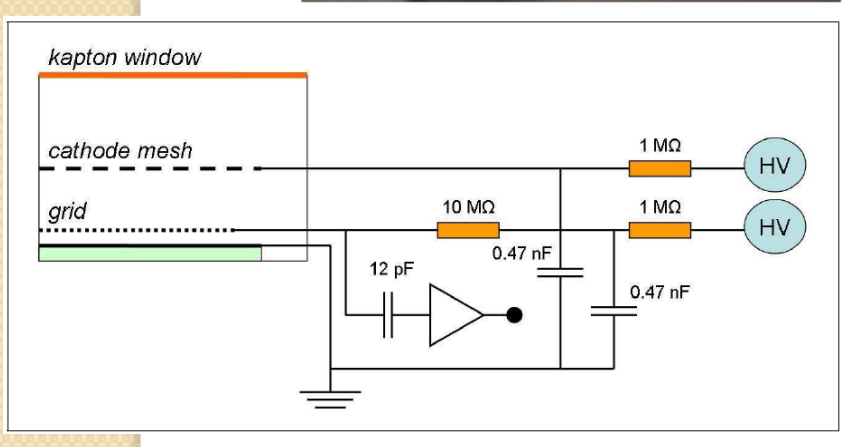




Experimental set-up

- NIKHEF test chamber
  - InGrid on bare wafer
  - Preamp/shaper/ADC
  - ^{55}Fe 5.9 keV X-ray source
  - Ar-based gas mixtures with iC_4H_{10} and CO_2





- At LAPP
  - Micro-Bulk from Irfu, Saclay
  - Chamber design from Nico
  - Strong 55Fe source
  - Mixtures of Ar/iso/CO2