DE LA RECHERCHE À L'INDUSTRIE

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DEVELOPMENT OF MICRO-TIME-OF-FLIGHT MASS SPECTROMETER FOR *IN SITU* GAS ANALYSIS

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INTRODUCTION AND CONTEXT

- *In Situ* gas analysis applications :

- Environment

- Industry

- Security

- Space

- Labs equipment's are heavy and bulky
- Field analysis require miniaturization → MEMS

GENERAL PRESENTATION

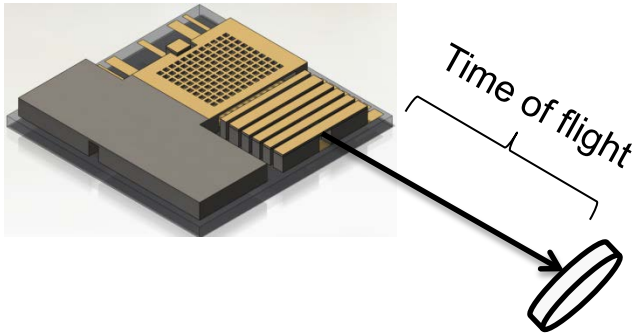
- Silicon chip 2 cm x 1 cm

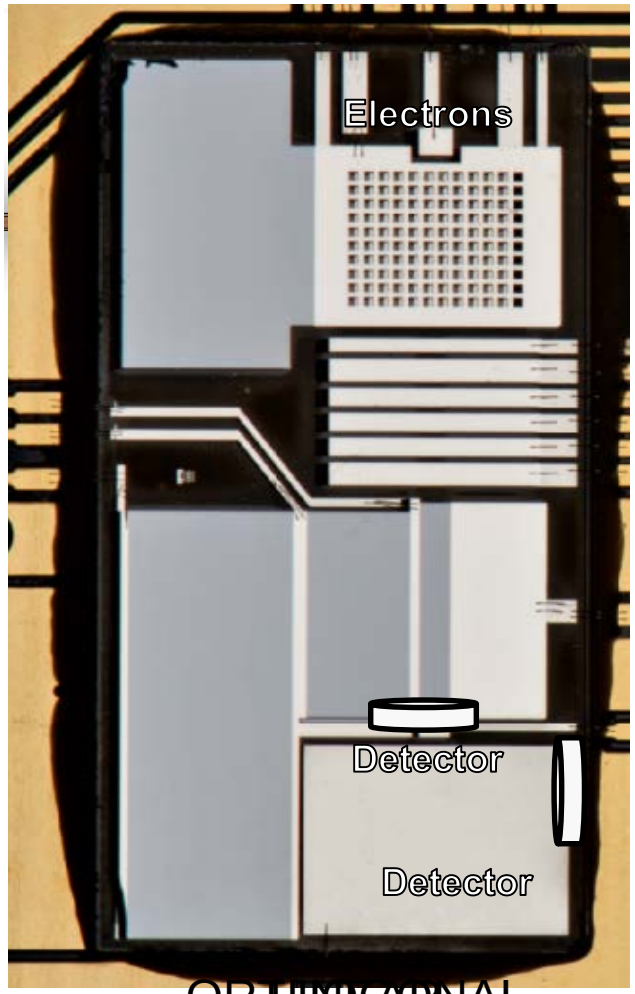
- Gas inlet (→ GC)
- Electronic Impact (EI) ionization (electrons gun)
- Extraction and focalization (electrostatic lenses)
- Detection (Micro Channel Plate) :

→ Linear : direct transmission, limited time of flight, geometric dispersion

→ Orthogonal : orthogonal injection and/or reflectron, longer time of flight

- Tuning using linear chip



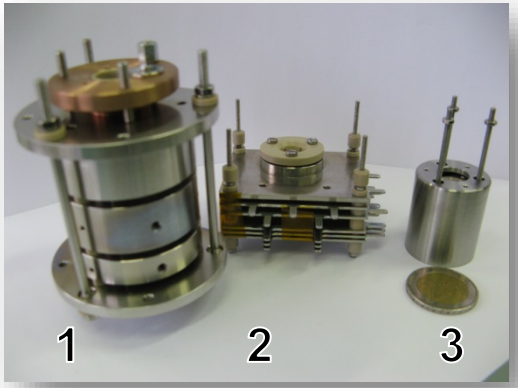


ORTHOGONAL

IONIZATION

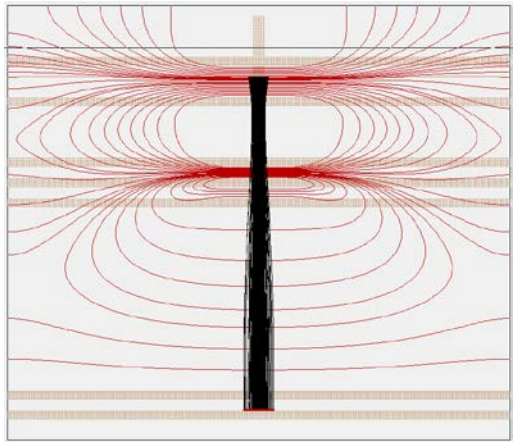
- Electrons gun
  - Tungsten filament
  - Electrostatic lenses
  - Gen. 3 smaller than 1 and 2

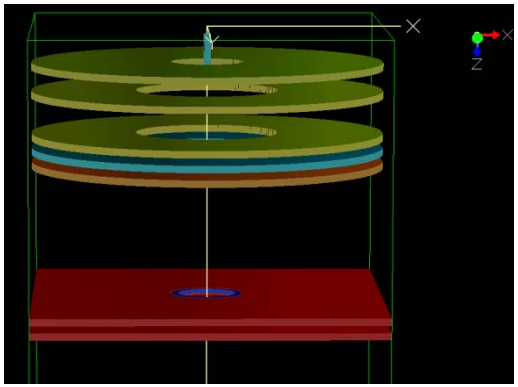
  → Allows closest approach of the chip



- Simulation benefits
  - Phenomena understanding
  - Iterative calculus for electrodes potentials

  - Wenhelt = -136.5 V
  - E1C = 188 V
  - E2C = 188 V
  - E3C = -108.5 V
  - E4C = -48 V





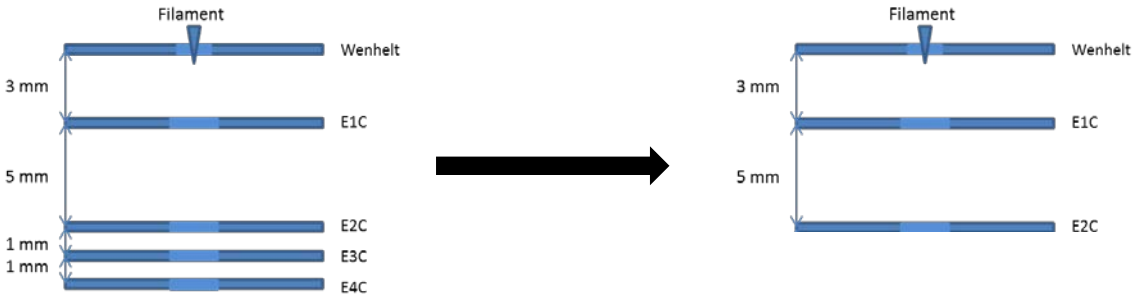
Modelization

  - Current intensity : -170 µA

IONIZATION

- Electron gun simplification

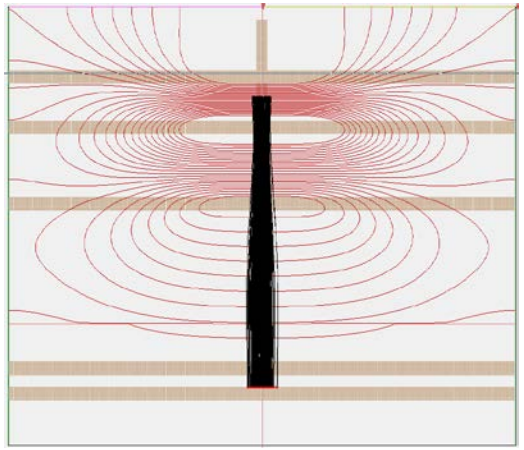
- From a 5 electrodes device to a 3 electrodes device

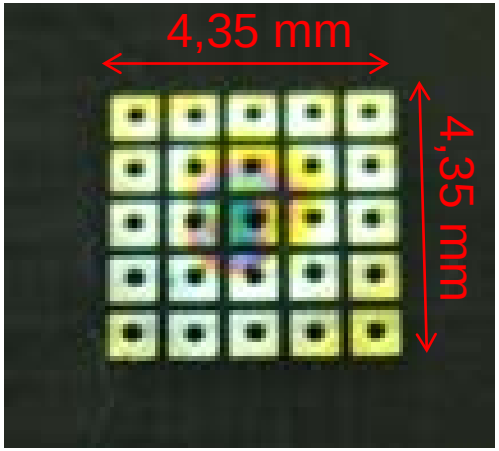


- Electron beam focalization ?

- Less settings for same results

  - Wenhelt = -115 V
  - E1C = 180 V
  - E2C = -100 V



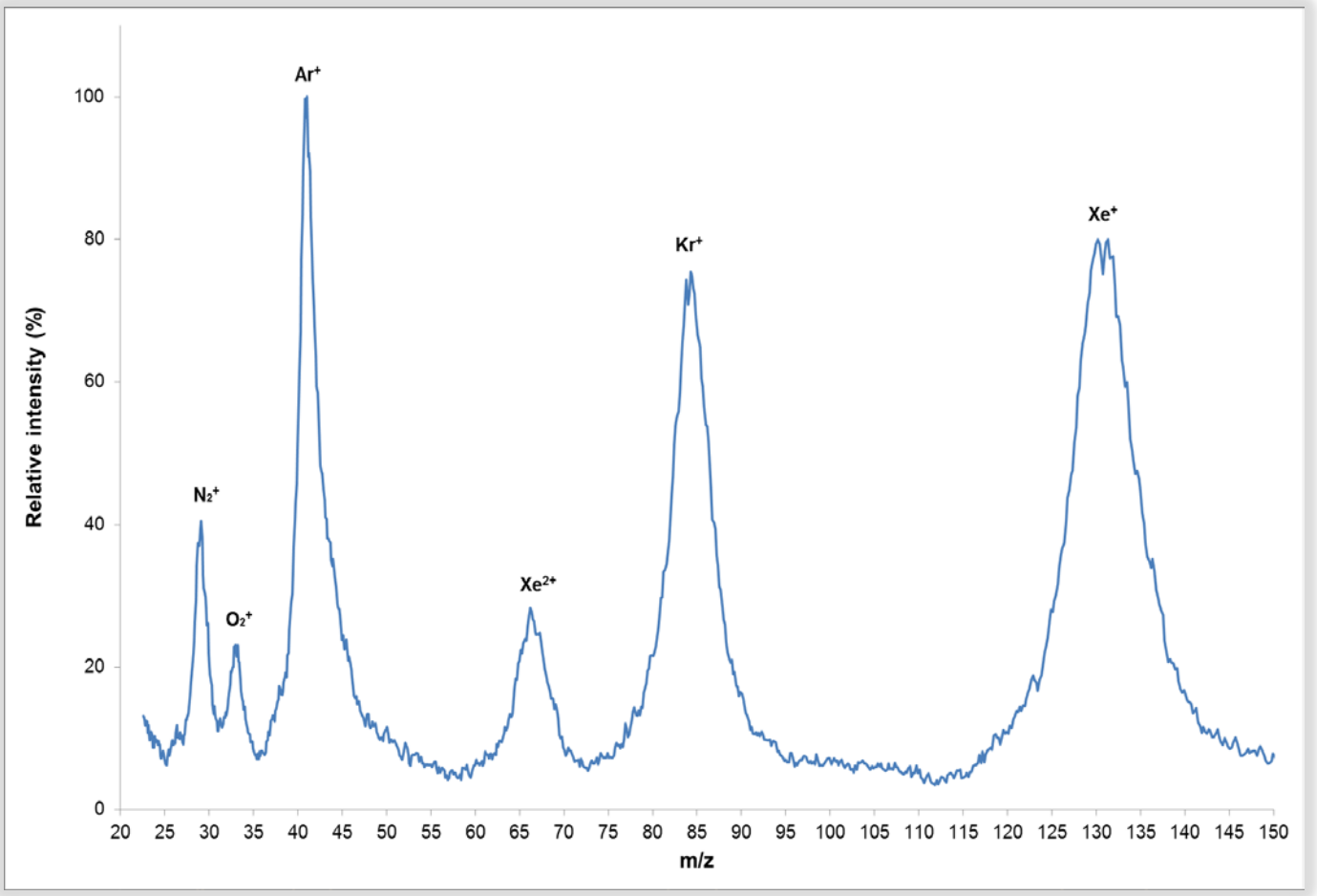


  - Current intensity : -165 µA

EXTRACTION AND FOCALIZATION

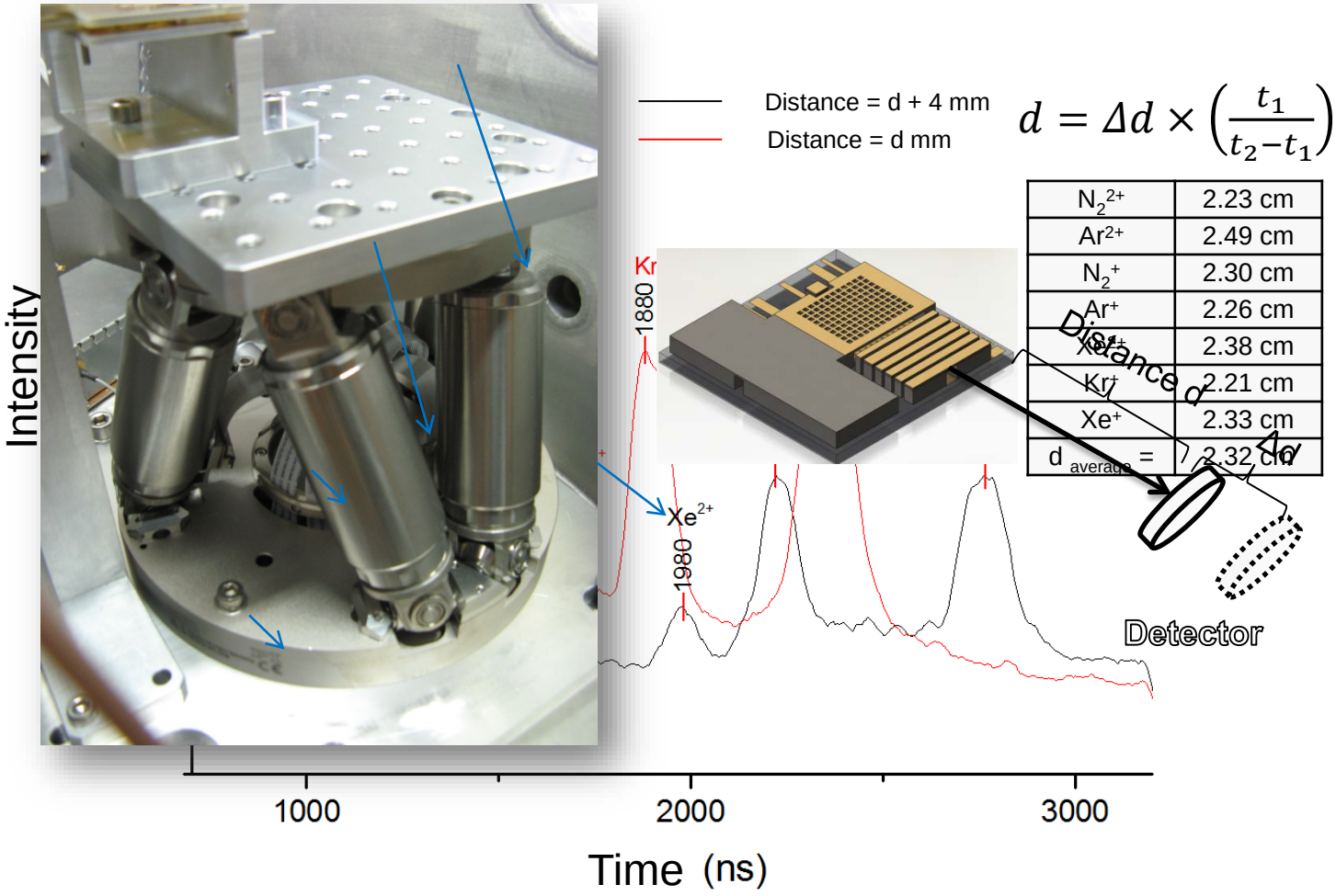
- Micro Channel Plate (MCP) detector
  - Time of flight measure → m/z

$$m/z = \left(\frac{t_{flight}}{d}\right)^2 \times 2 \times V$$



EXTRACTION AND FOCALIZATION

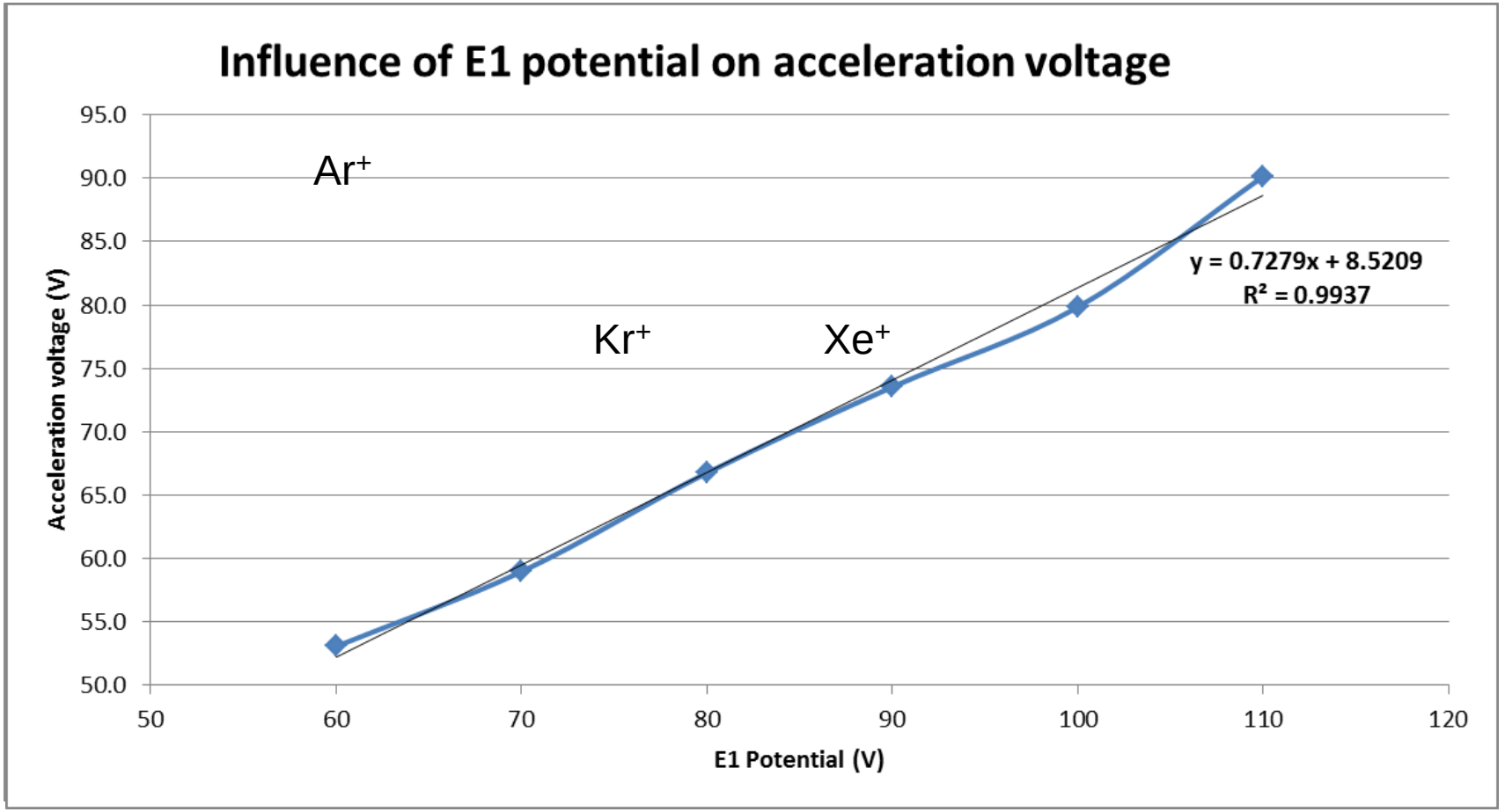
- Determination of d using Δd
  - Change of flight distance by moving the hexapod : Δd = 4 mm



EXTRACTION AND FOCALIZATION

- Acceleration voltage

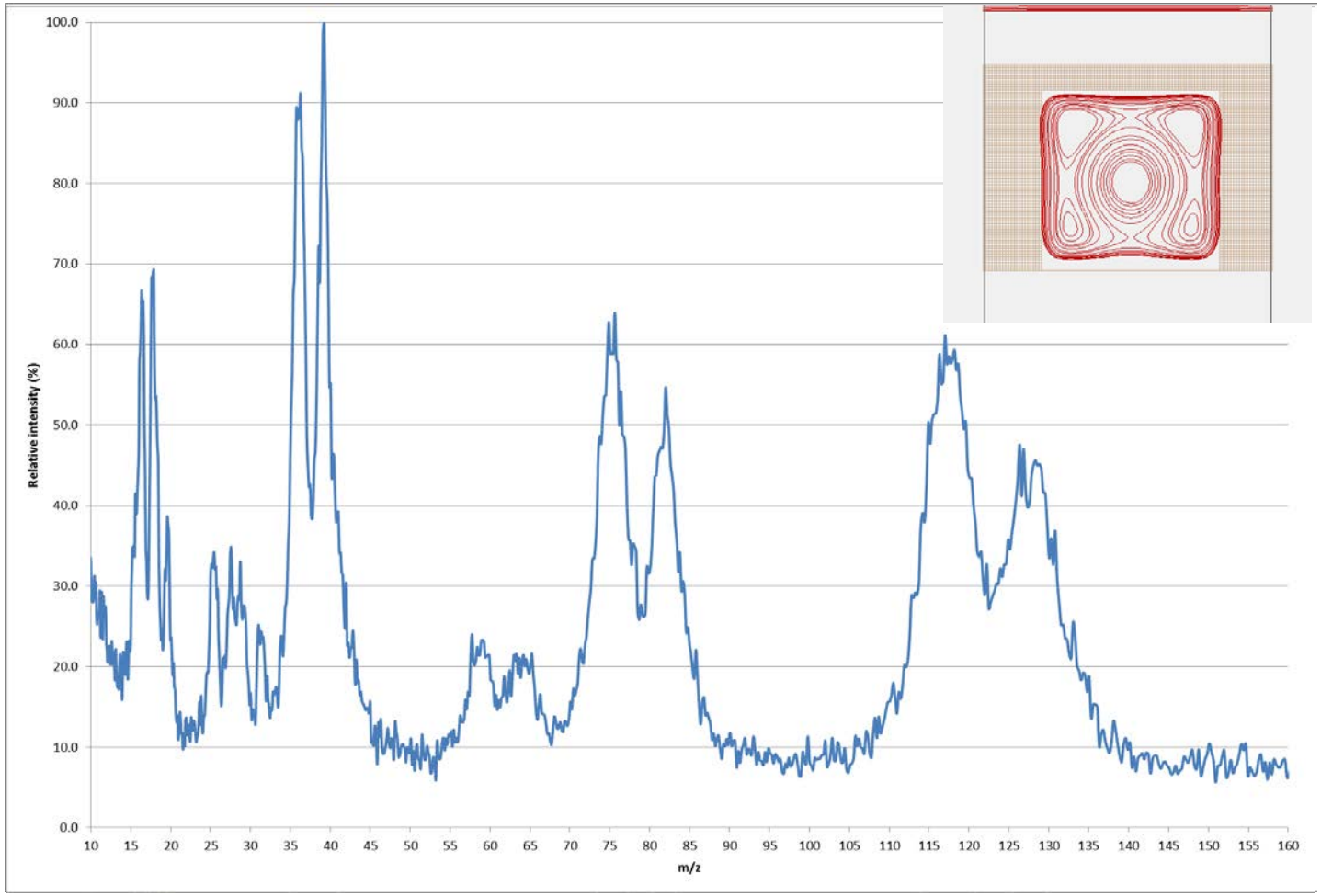
$$t_{vol} = \frac{d}{\sqrt{2 \times V}} \times \sqrt{m/z}$$



→ E1 electrode has the predominant effect beside others electrodes

EXTRACTION AND FOCALIZATION

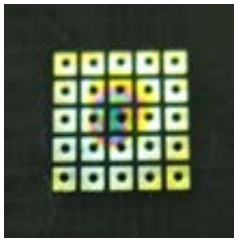
- Side effect of square shaped electrodes : electric fields concatenation ?



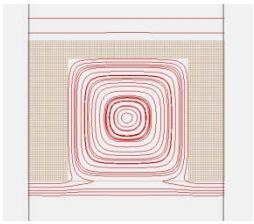
CONCLUSION AND PERSPECTIVES

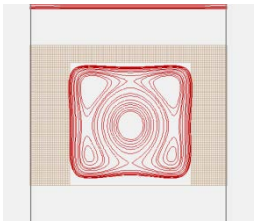
- **Results reproductibility**
  - Stable system and settings

- **Good focalization of the electrons beam**
  - Geometric dispersion to correct
  - Keeping a good ionization yield

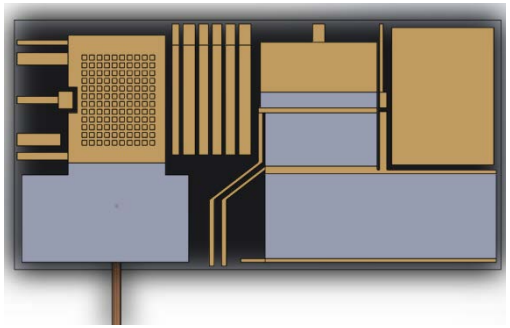


- **Important parameters fixed**
  - Influence on time of flight:
    - E1 effect on acceleration voltage
    - Ionization area effect
  - Electric fields to be precisely tuned





- **Other parameters**
  - Maximize peaks intensity
  - Refine peaks
    - → MCP electronics
    - → Orthogonal injection



THANK YOU

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