Developments on ions/electrons facilities for gas detector characterization

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Outline

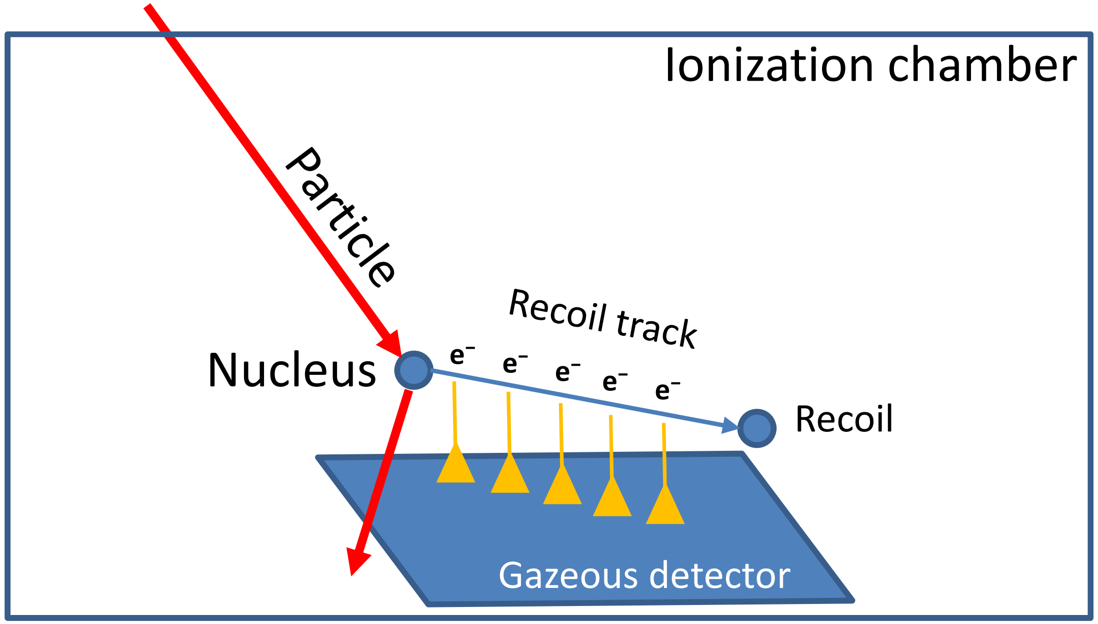
- Introduction
- The 1 µm pressure interface
- LHI (Ligne Haute Intensité) facility
- COMIMAC table top facility
  - Electron performances
  - Ion performances
  - Spherical gaseous detector tests
  - COMIMAC @IRSN-Cadarache
- Conclusion

Introduction

Nuclear recoils:

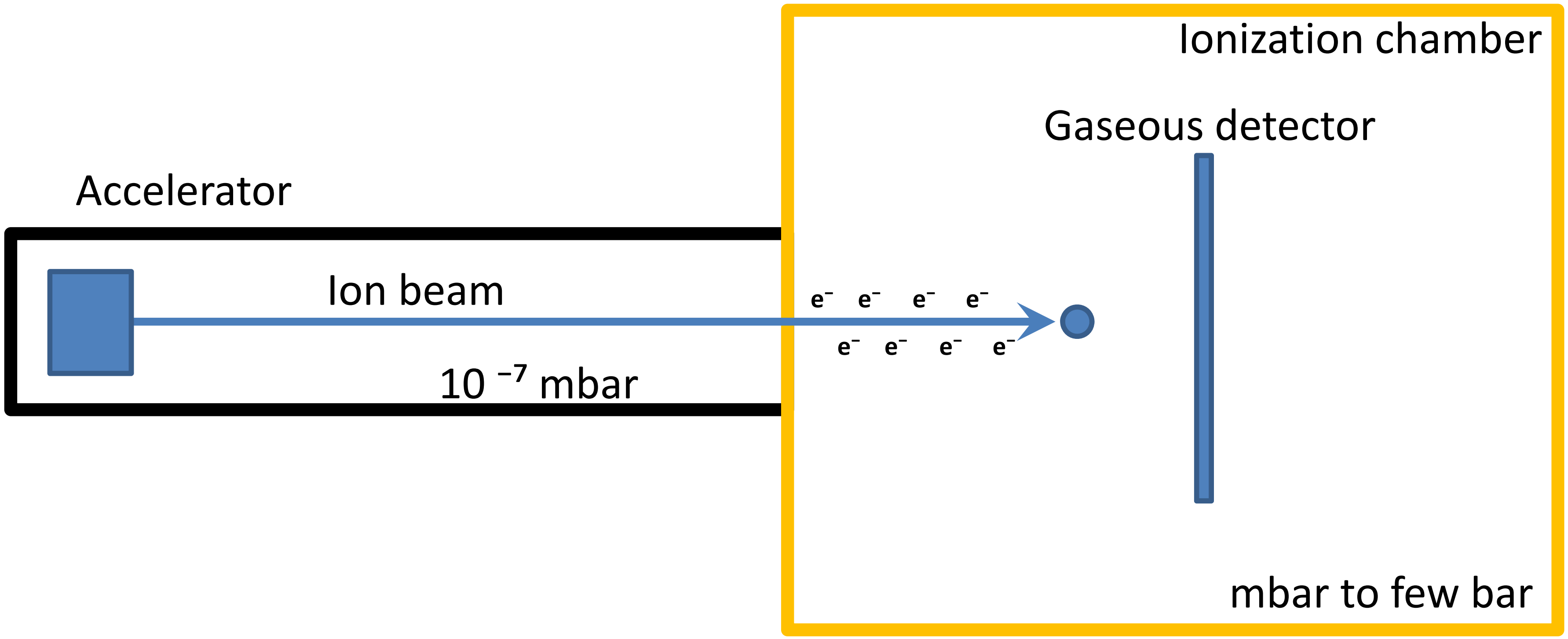
- Nuclear recoil produced by elastic scattering are used to detect neutral particles (Neutrons, Dark Matter WIMPS)

- ✓ Energy
- ✓ Direction
- ✓ 3D Track reconstruction



- For low energy recoils (few keV) only a certain fraction of the recoil energy is deposited in the ionization chanel -> Quenching

Working principle



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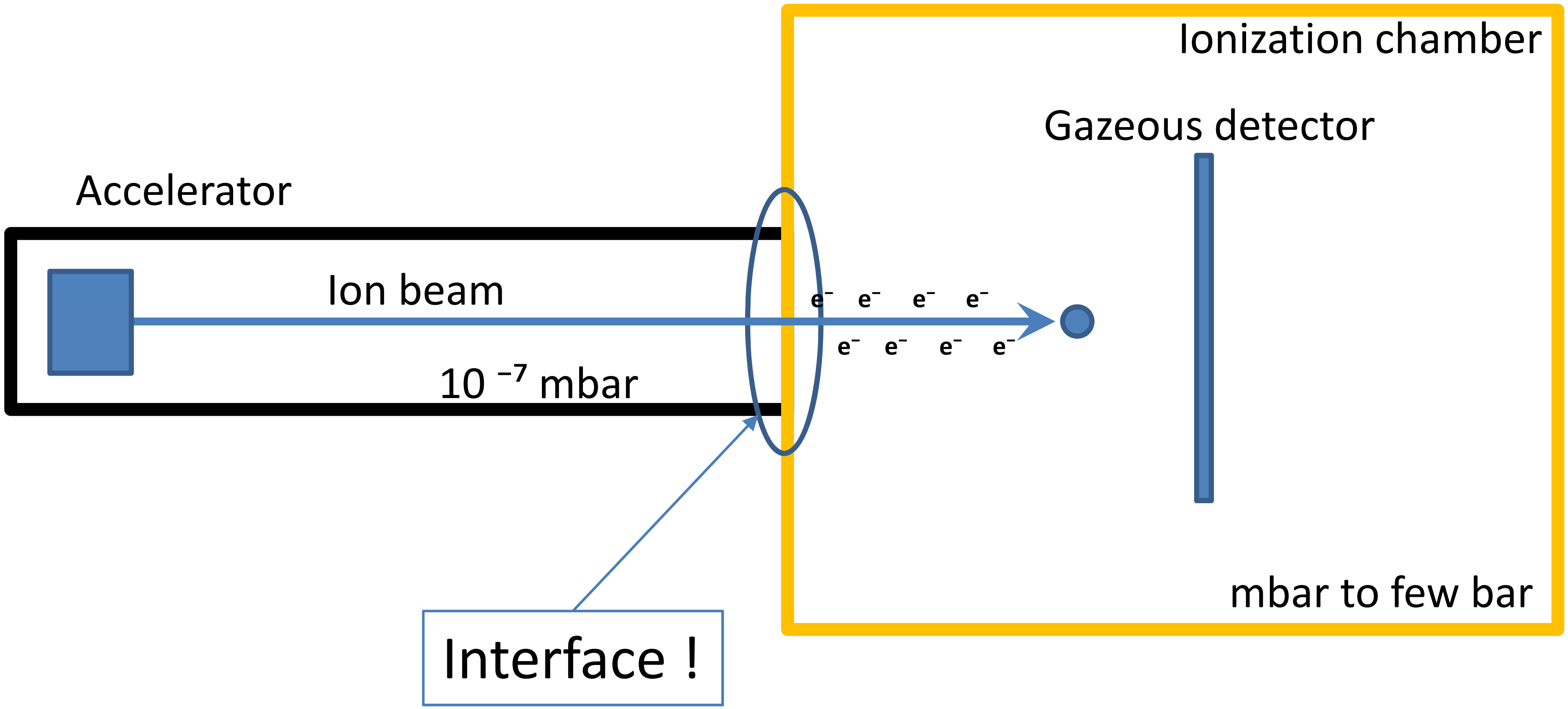
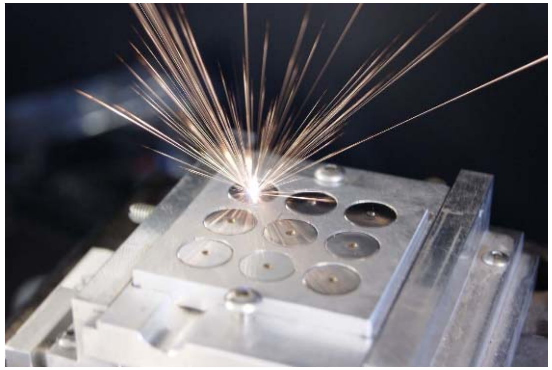


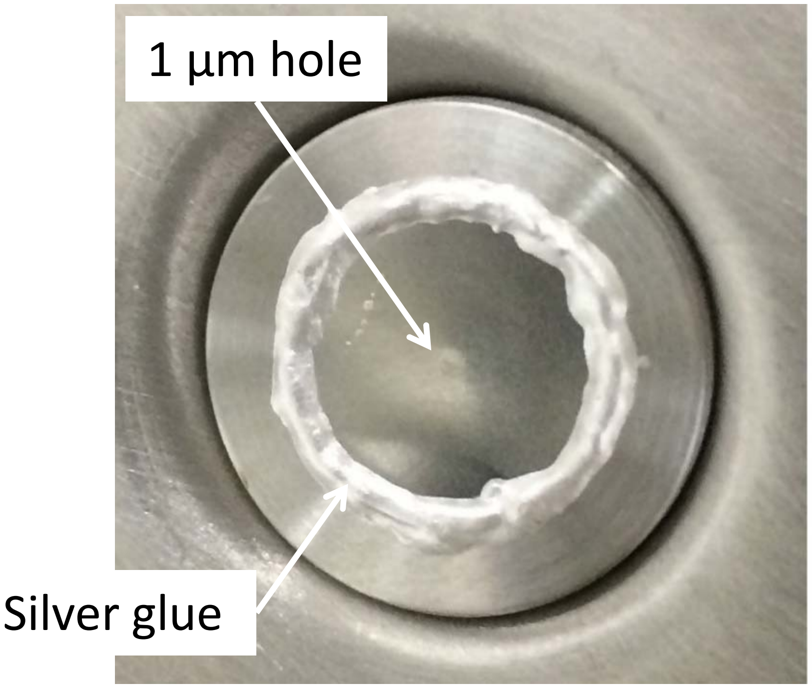
1µm Pressure Interface

- 13 µm stainless steel window
- 1 µm hole laser drilled

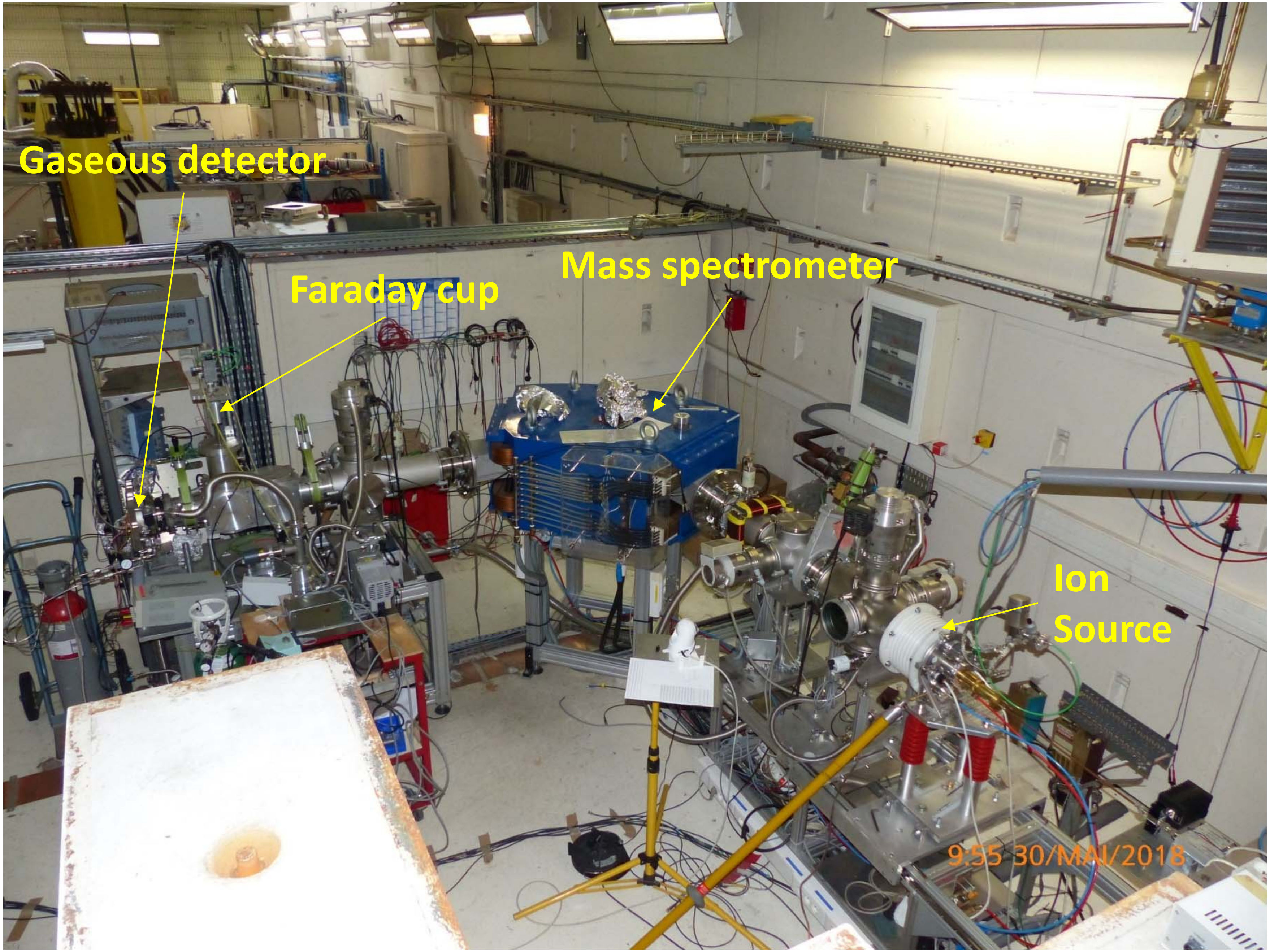


➢ Allow a pressure ratio btw the source (10^{-7} mbar) and the ionization chamber (0-10 bar)

➢ Leave ion or electron beams entering into the ionization chamber

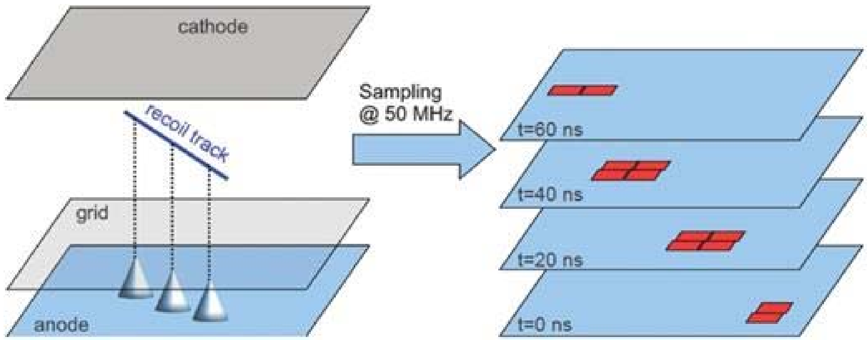


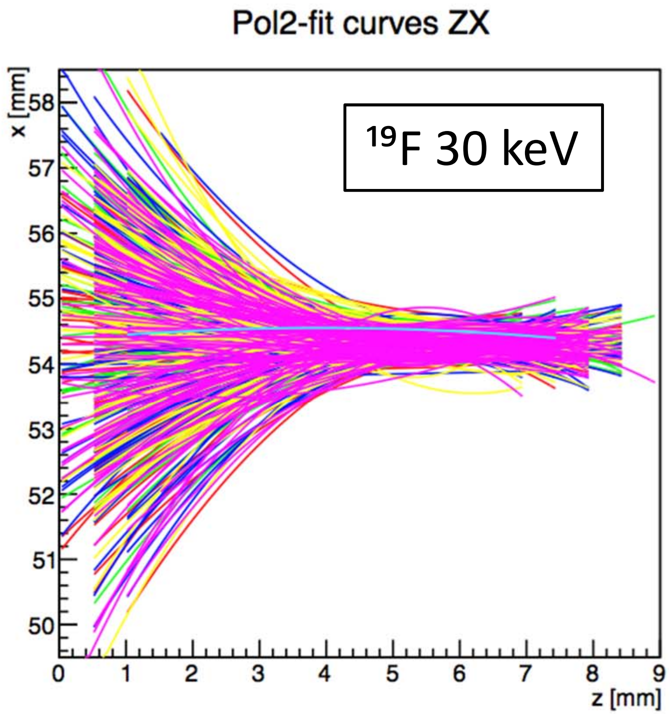
Beam ligne: LHI @LPSC

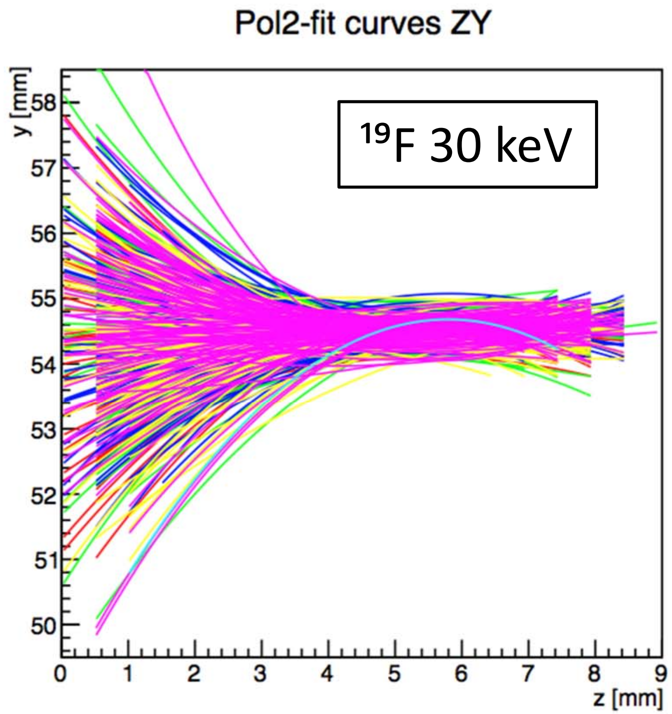


3D recoil tracks on LHI @LPSC

µTPC MIMAC
µmegas (100 x 100 mm²)
512 channels
Fast electronic (20 ns)

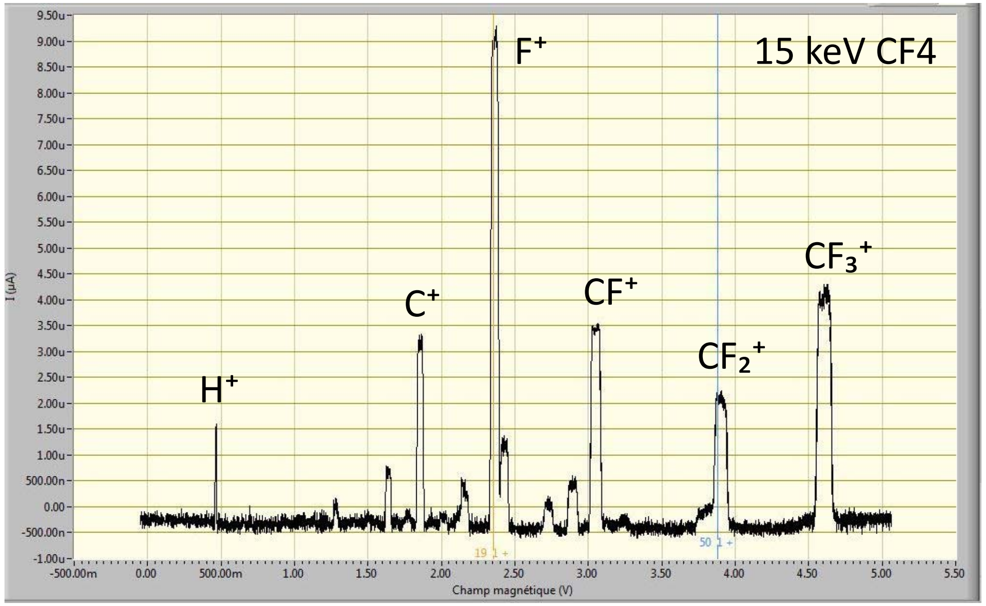






Beam ligne: LHI @LPSC

- Very nice facility
- Very good ions selectivity with the dipole



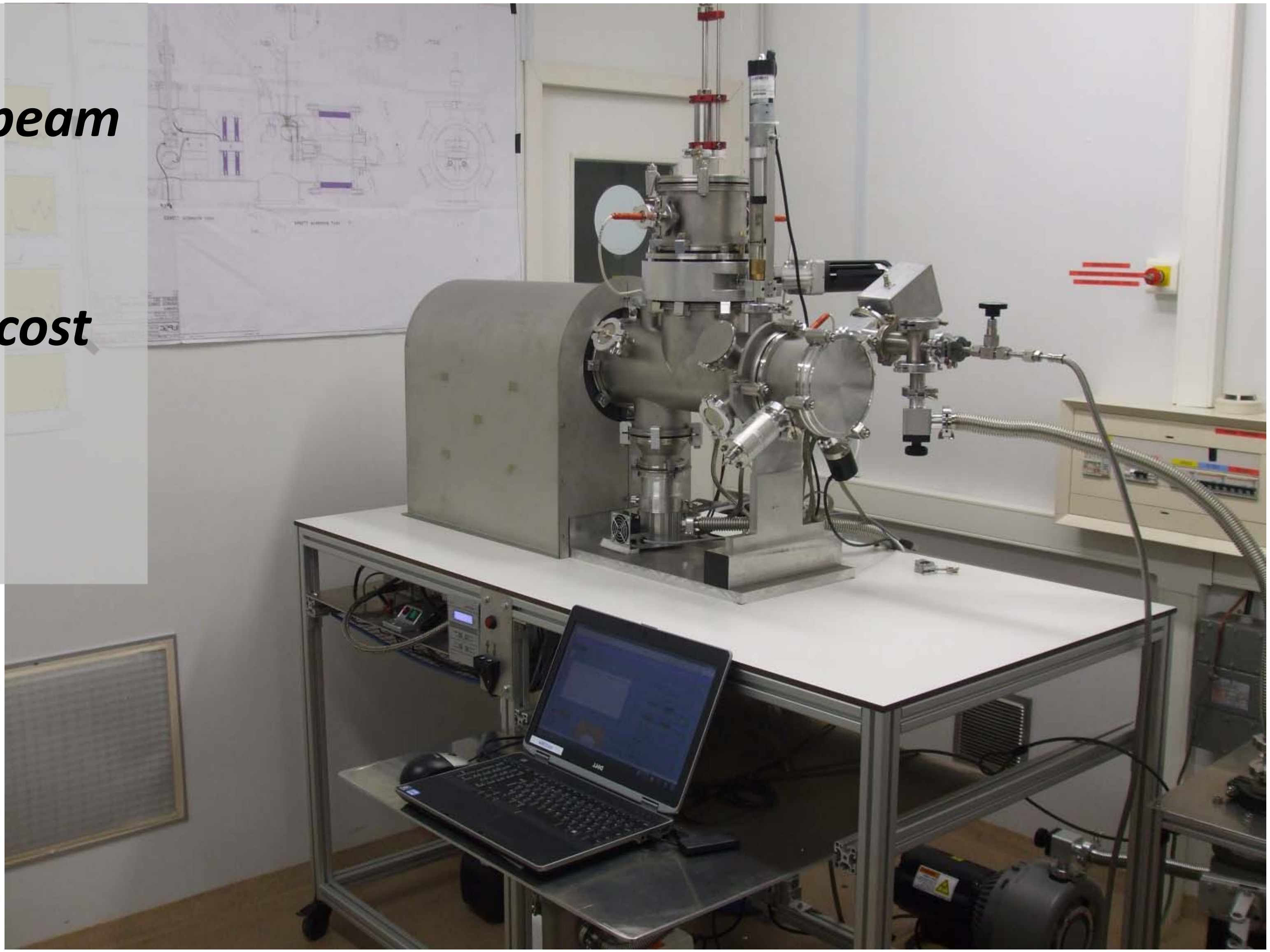
<u>But:</u>

- Large facility, expensive running costs (5 turbo pumps, 200 A dipole magnet)
- Not dedicated to gaseous detector developments
- Need to use radioactive sources for calibration
  - For low pressure gases, X-rays sources are inefficient due to gas transparency
  - Sources must hide to avoid impact on datas
  - Multiple sources are required to have several reference points

As we have a plasma source, why not extracting and using <u>**electrons**</u> for calibration?

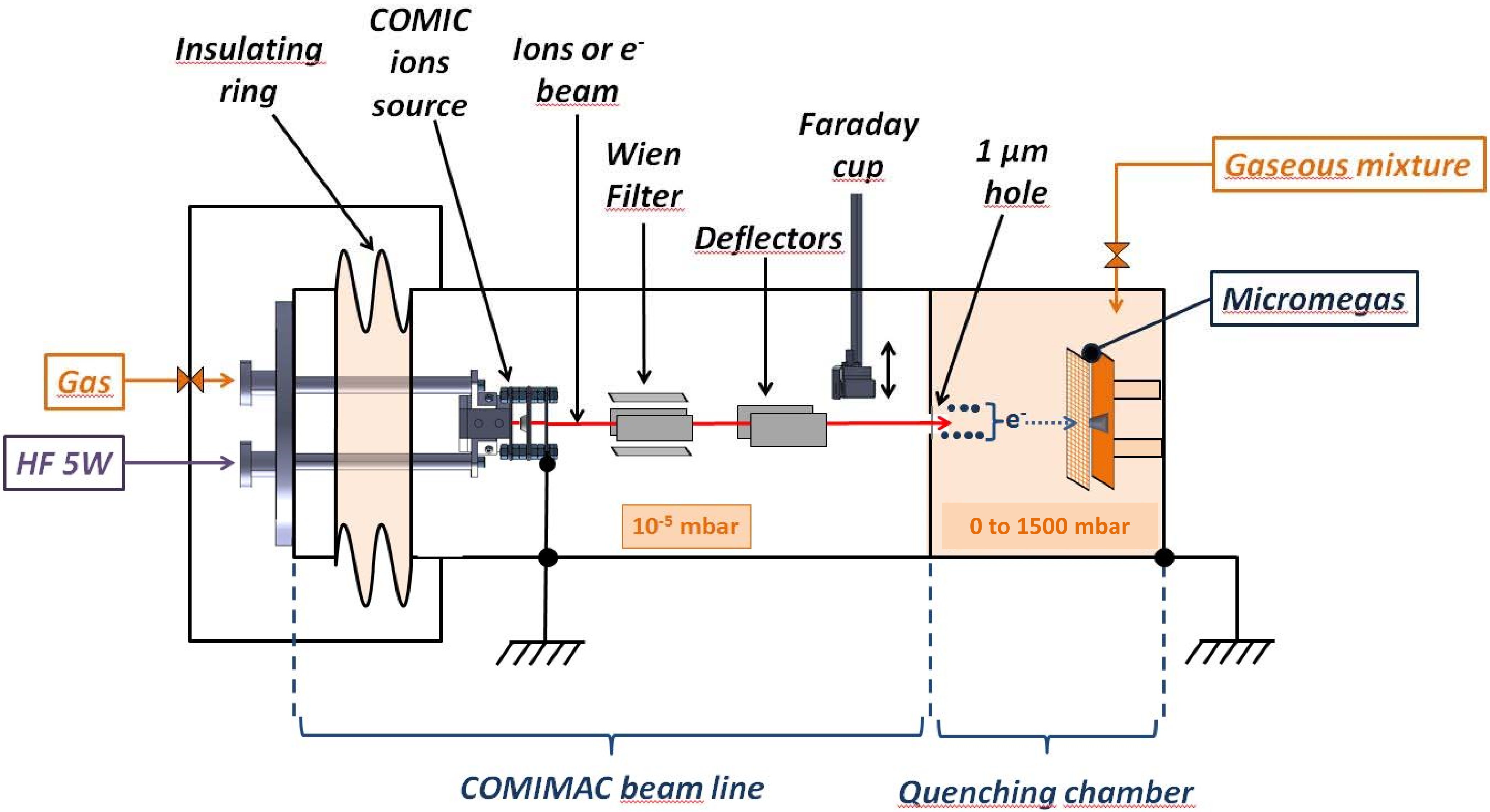
COMIMAC : a table top facility

- ***50 keV***
- ***Ion & electron beam***
- ***Linear***
- ***Compact***
- ***Cheap running cost***
- ***Transportable***



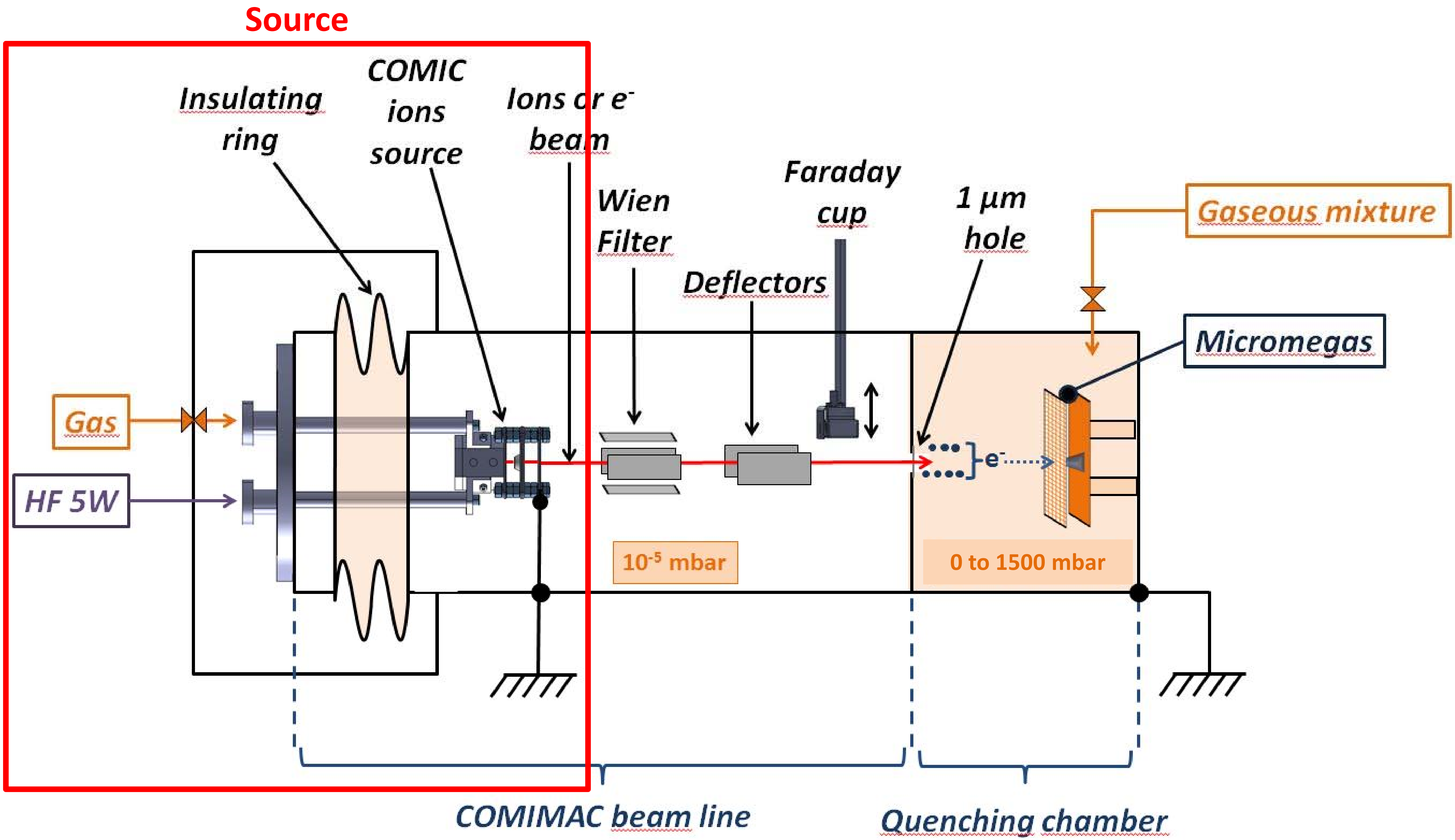
NIM-A 832 (2016) : A table-top ion and electron beam facility for ionization quenching measurement and gas detector calibration

COMIMAC



Insulating ring
COMIC ions source
Ions or e⁻ beam
Wien Filter
Deflectors
Faraday cup
1 µm hole
Gaseous mixture
Micromegas
Gas
HF 5W
e⁻
10⁻⁵ mbar
0 to 1500 mbar
COMIMAC beam line
Quenching chamber

COMIMAC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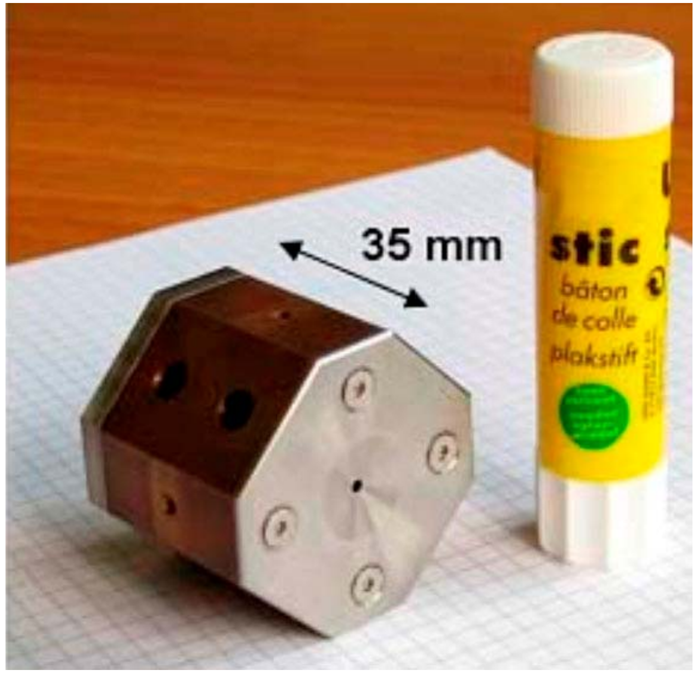
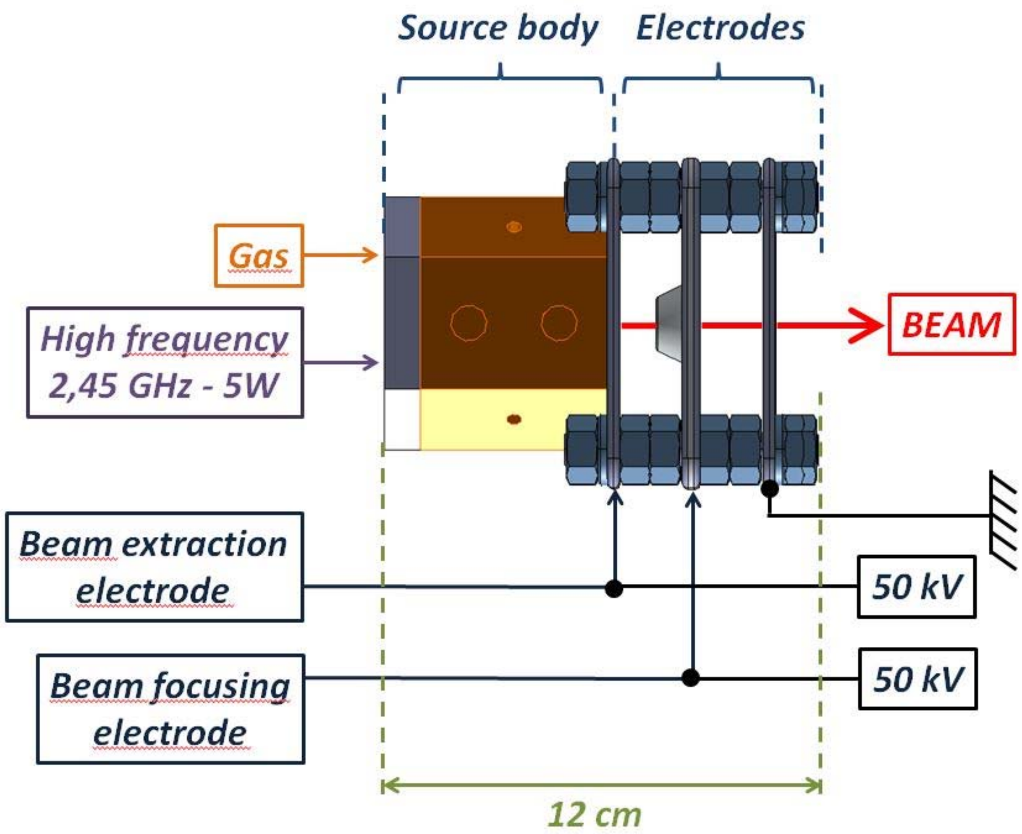
0 to 1500 mbar
COMIMAC beam line
Quenching chamber

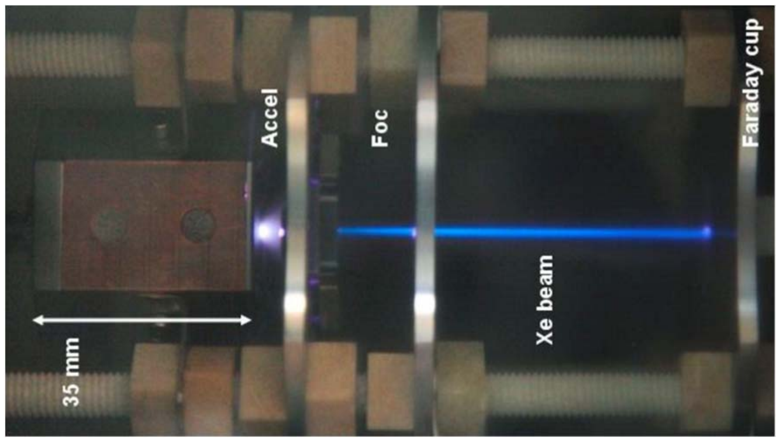
Highly Compacted Source

COMIC *"**CO**mpact **Mi**crowave **C**oaxial"* is an highly compacted **E**lectron **C**yclotron **R**esonance (ECR) source developed at LPSC by SSI Group.

Pulsed at 2.45 GHz (5W), the current density can reached 10 mA/cm^2.

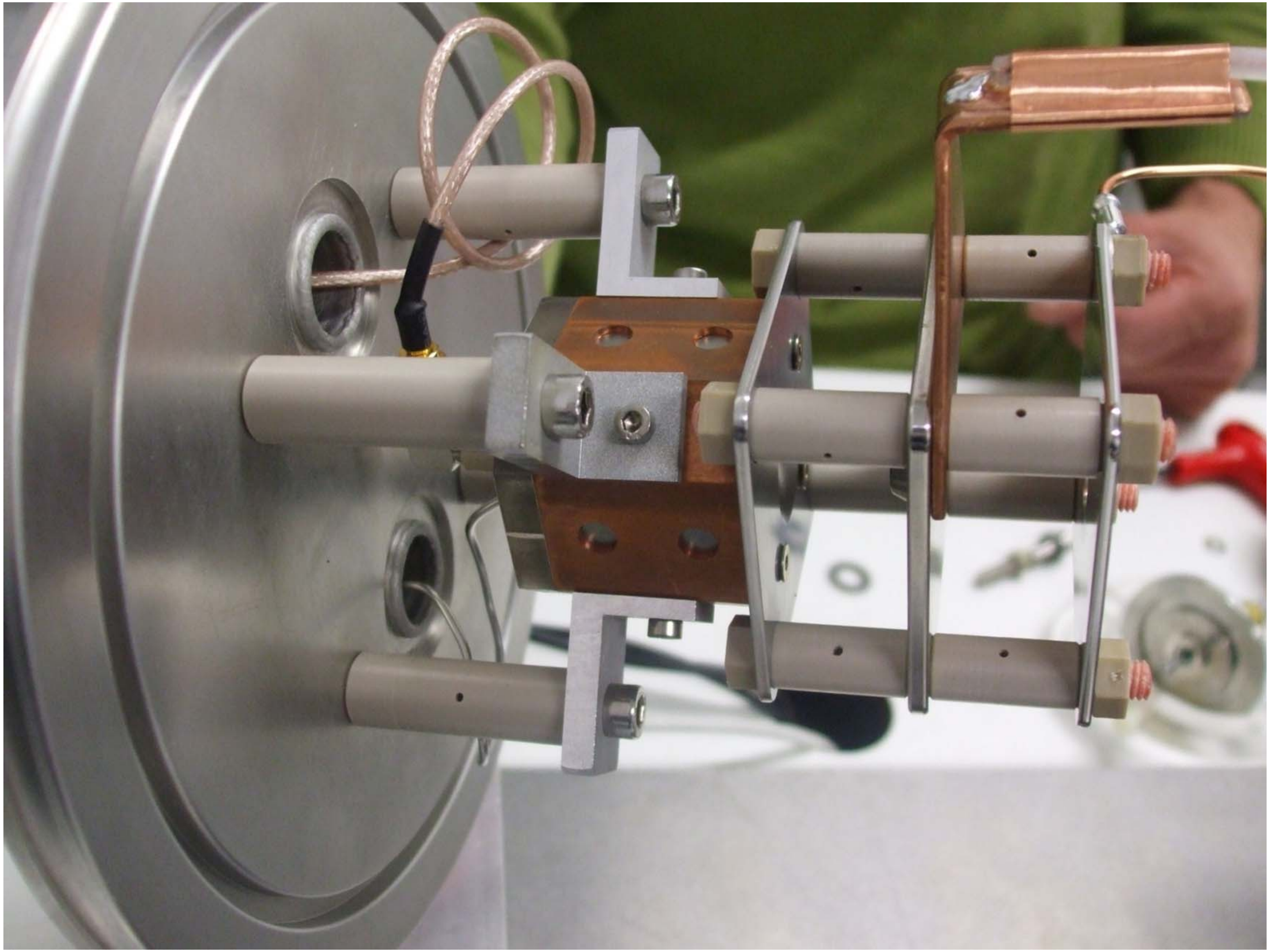




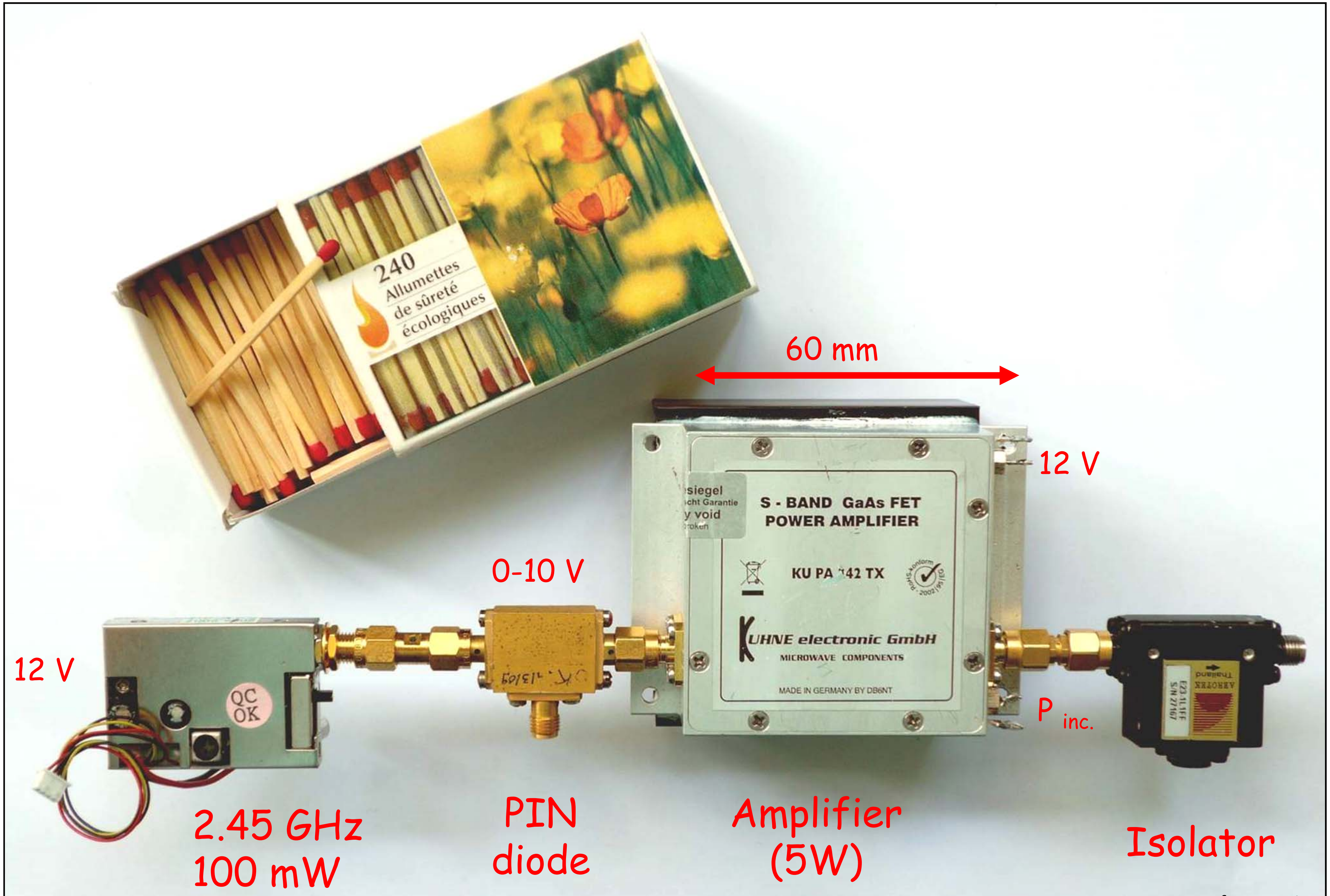


Countersy of P.Sortais

Highly Compacted Source



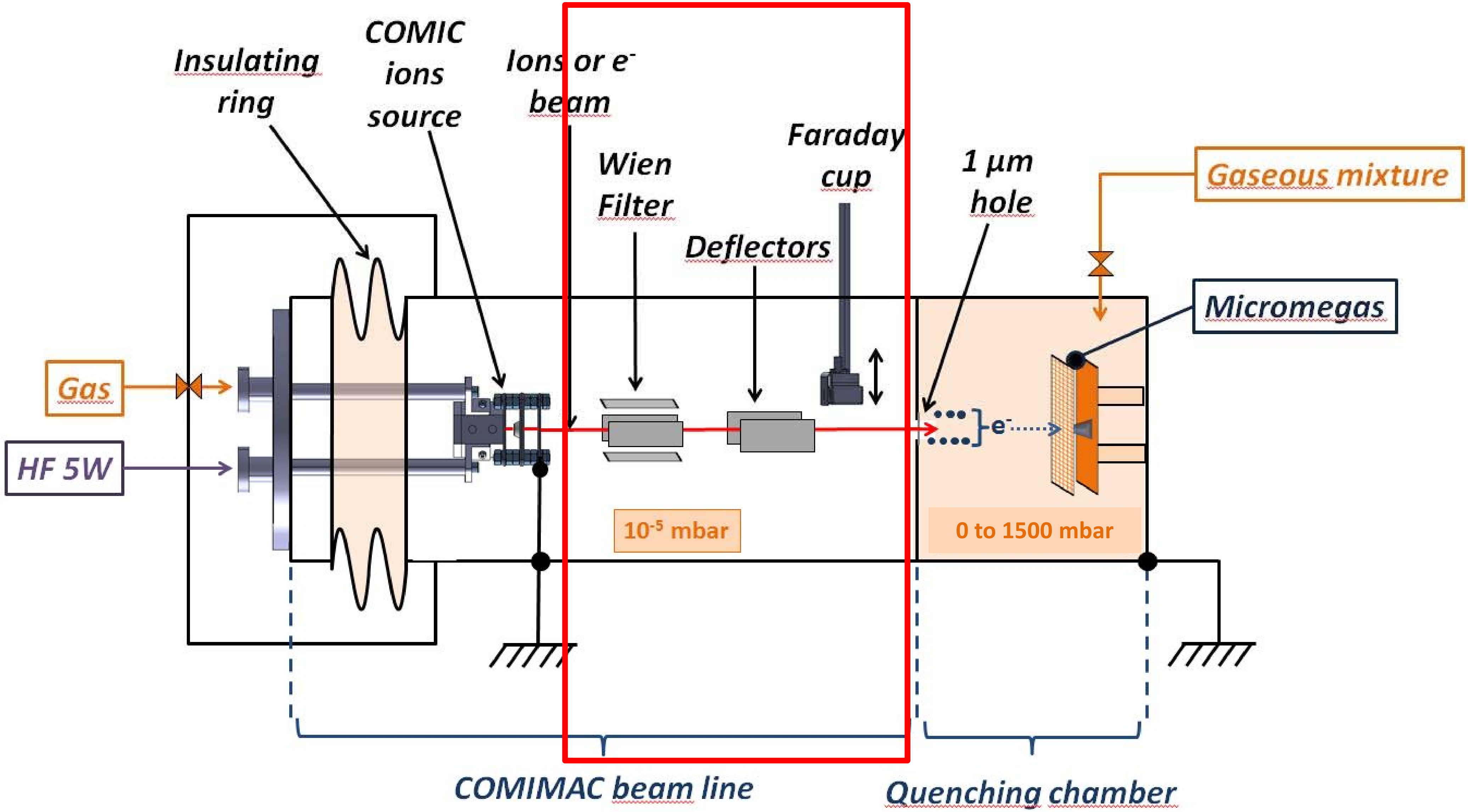
Miniaturized RF Power



Countersy of P.Sortais

COMIMAC

Beam Monitoring



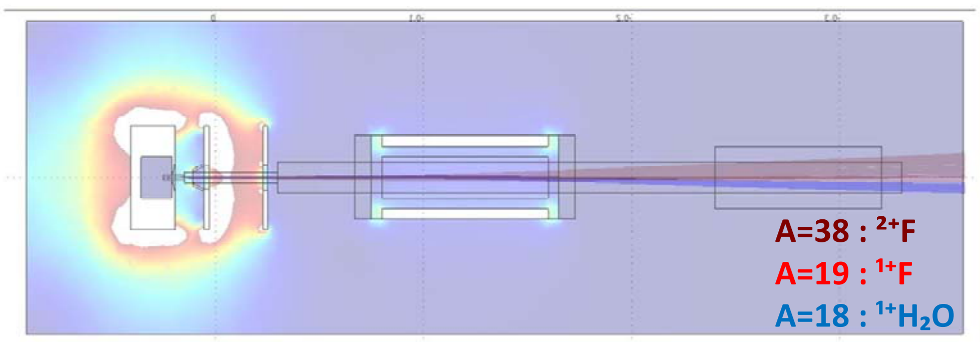
Wien Filter

Aim:

- Make a q/m selection of ions

Combination of:

- 0.36 Tesla vertical magnetic field produced by 2 permanent magnets
- 3.3 kV/cm horizontal electric field



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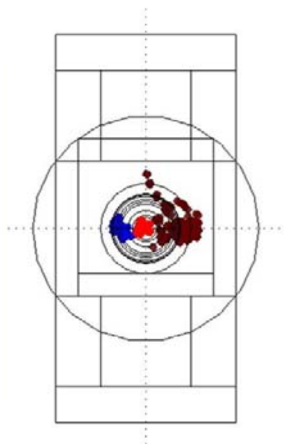

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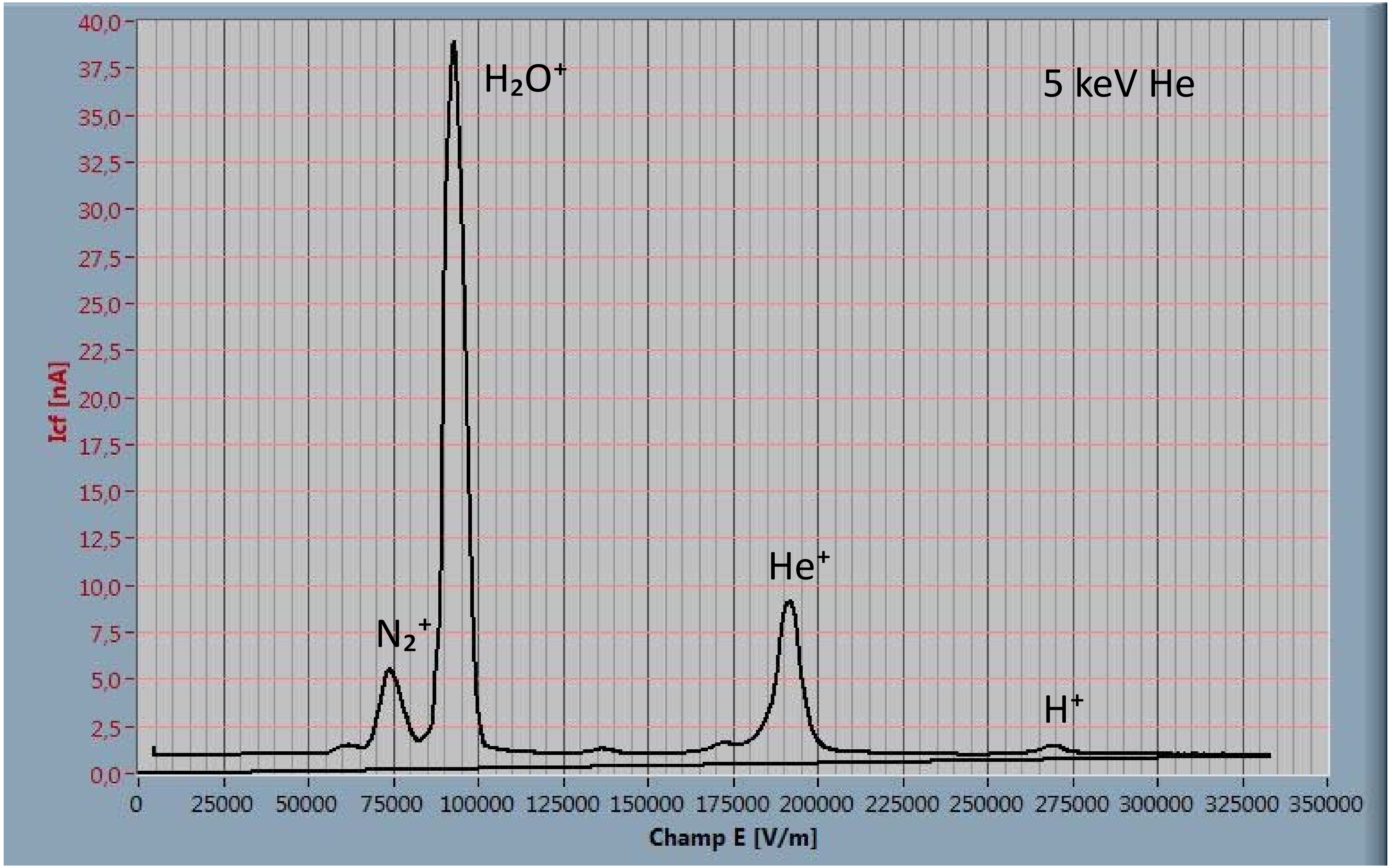
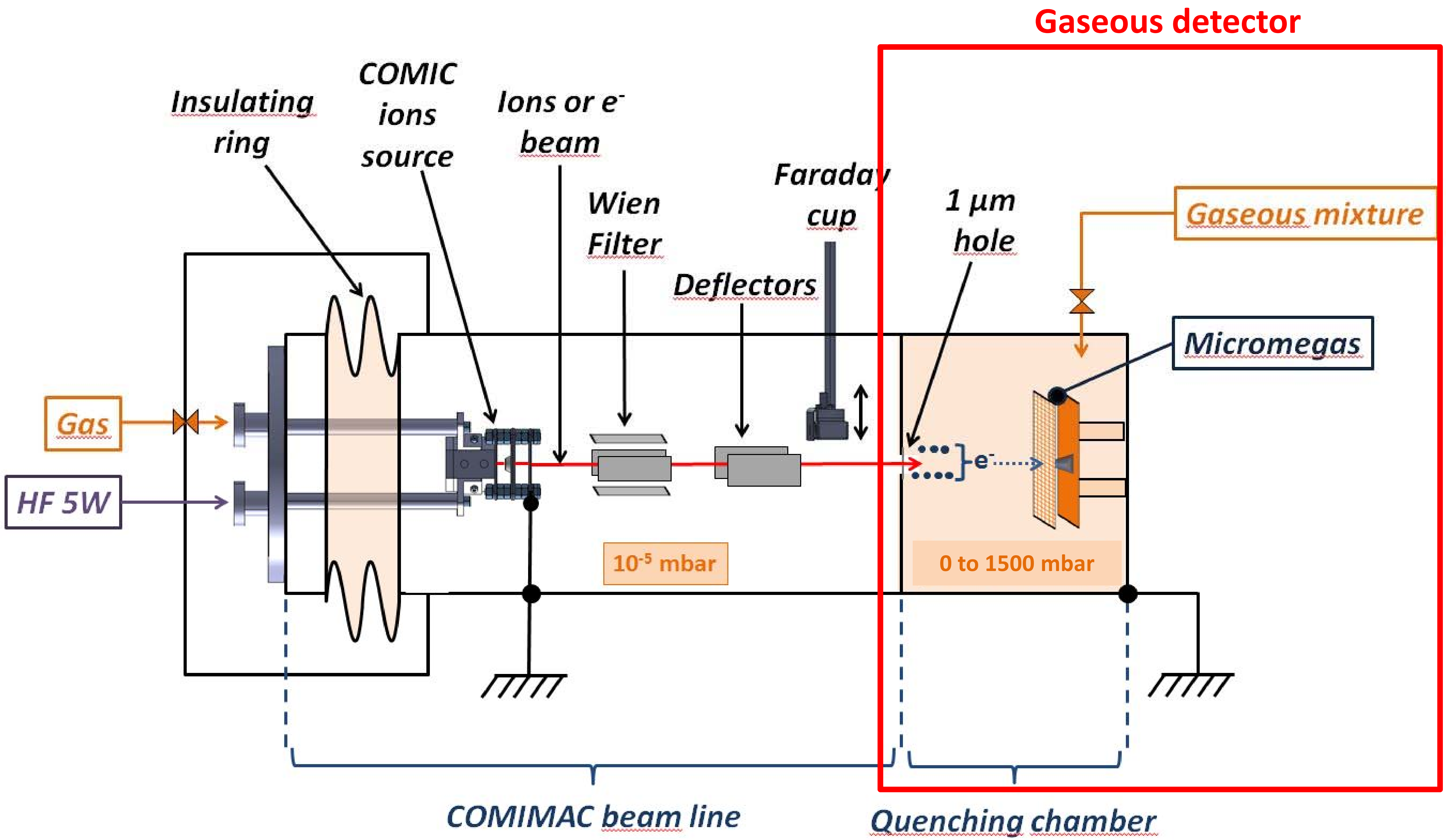
Wien Filter

Wien filter spectrum on the faraday cup



COMIMAC


Gaseous detector
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Ions or e- beam
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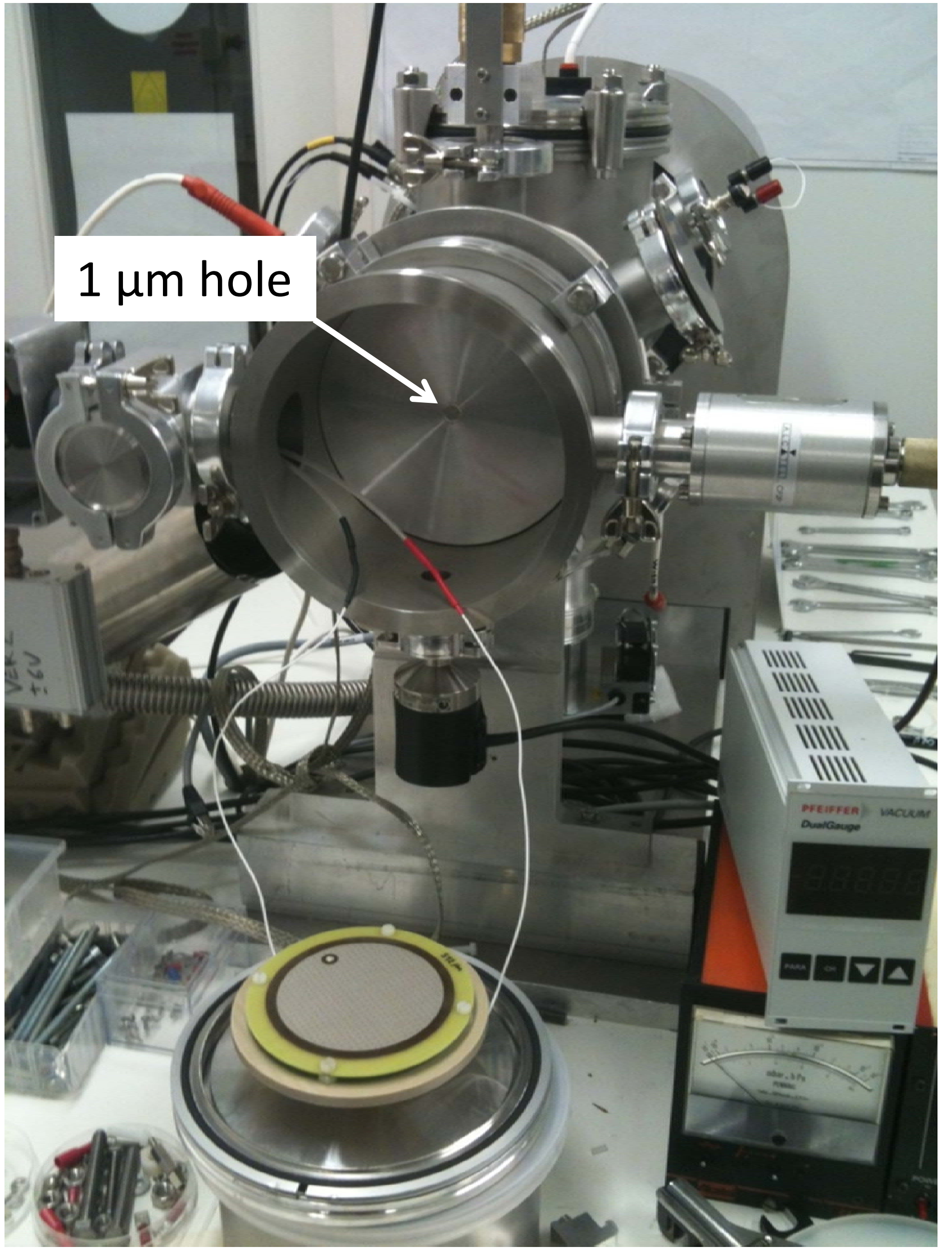
COMIMAC beam line
Quenching chamber

COMIMAC@LPSC

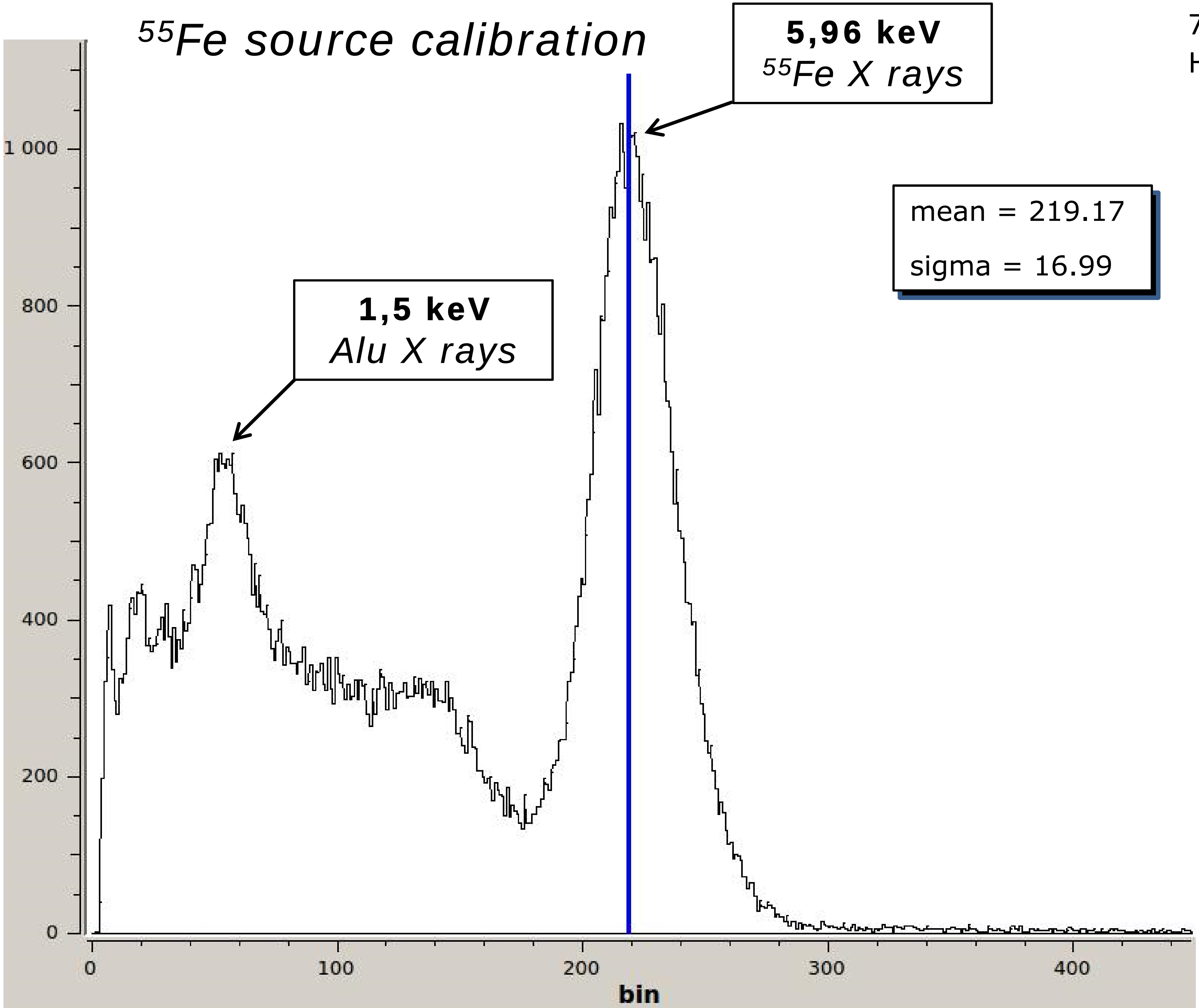


Setup:

- Chamber volume : 2 liters
- 128, 256 or 512 µm micromegas (Ø 60 mm, produced @ CERN)
- Drift distance: 60 mm
- Calibration using ^{55}Fe source *(5,96 keV)*

Electrons Performance

700 mbar
He + 5% C_4H_{10}



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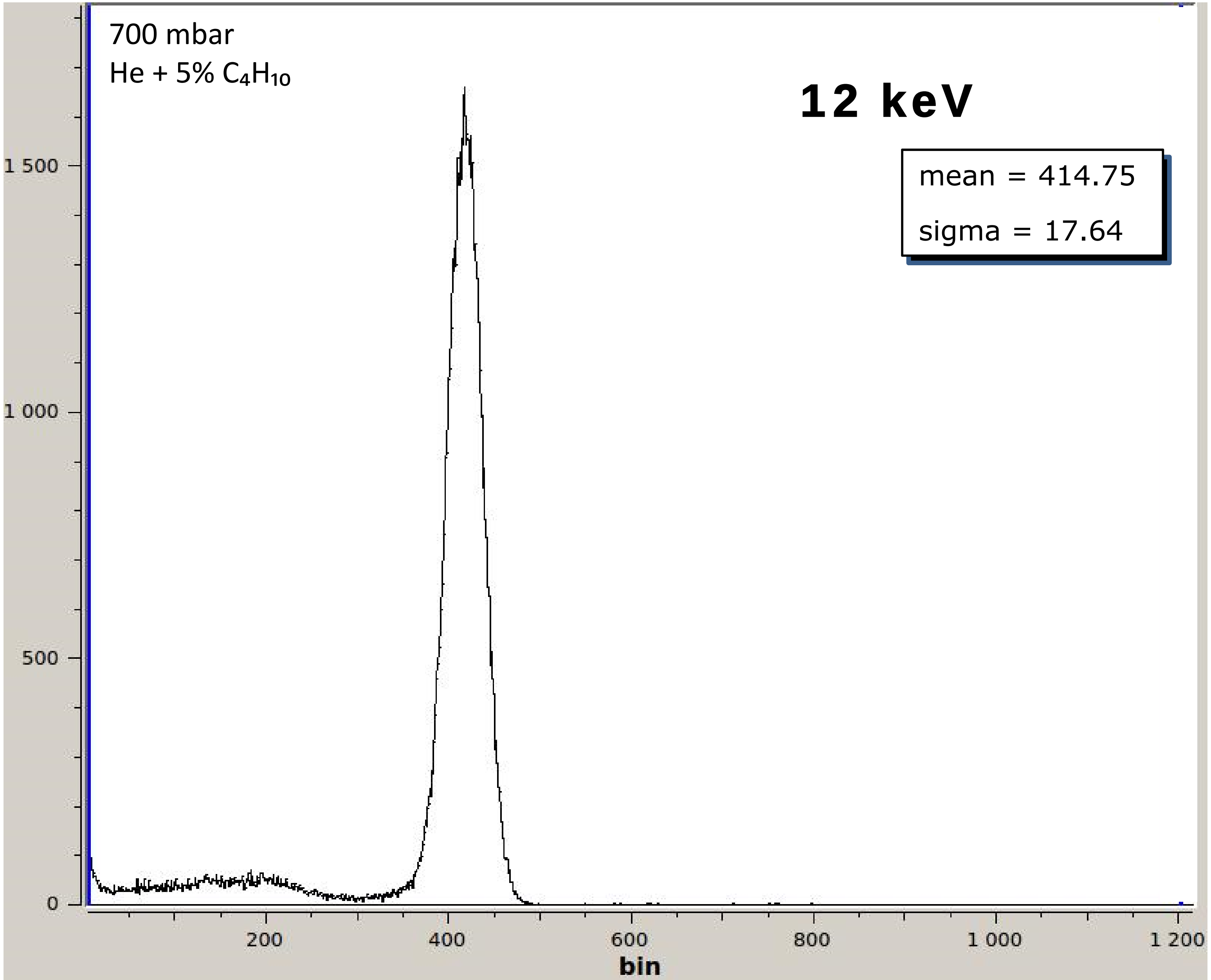

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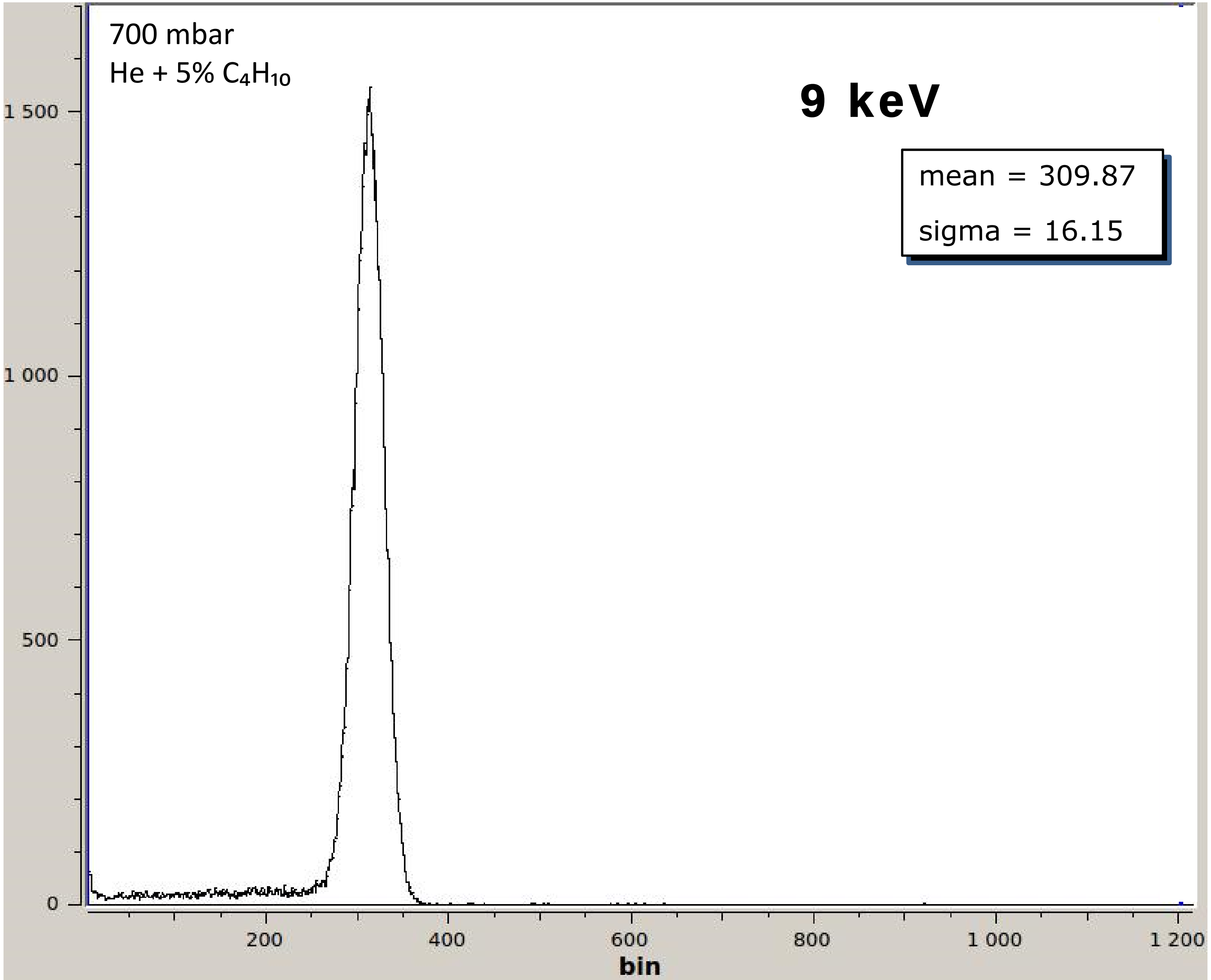

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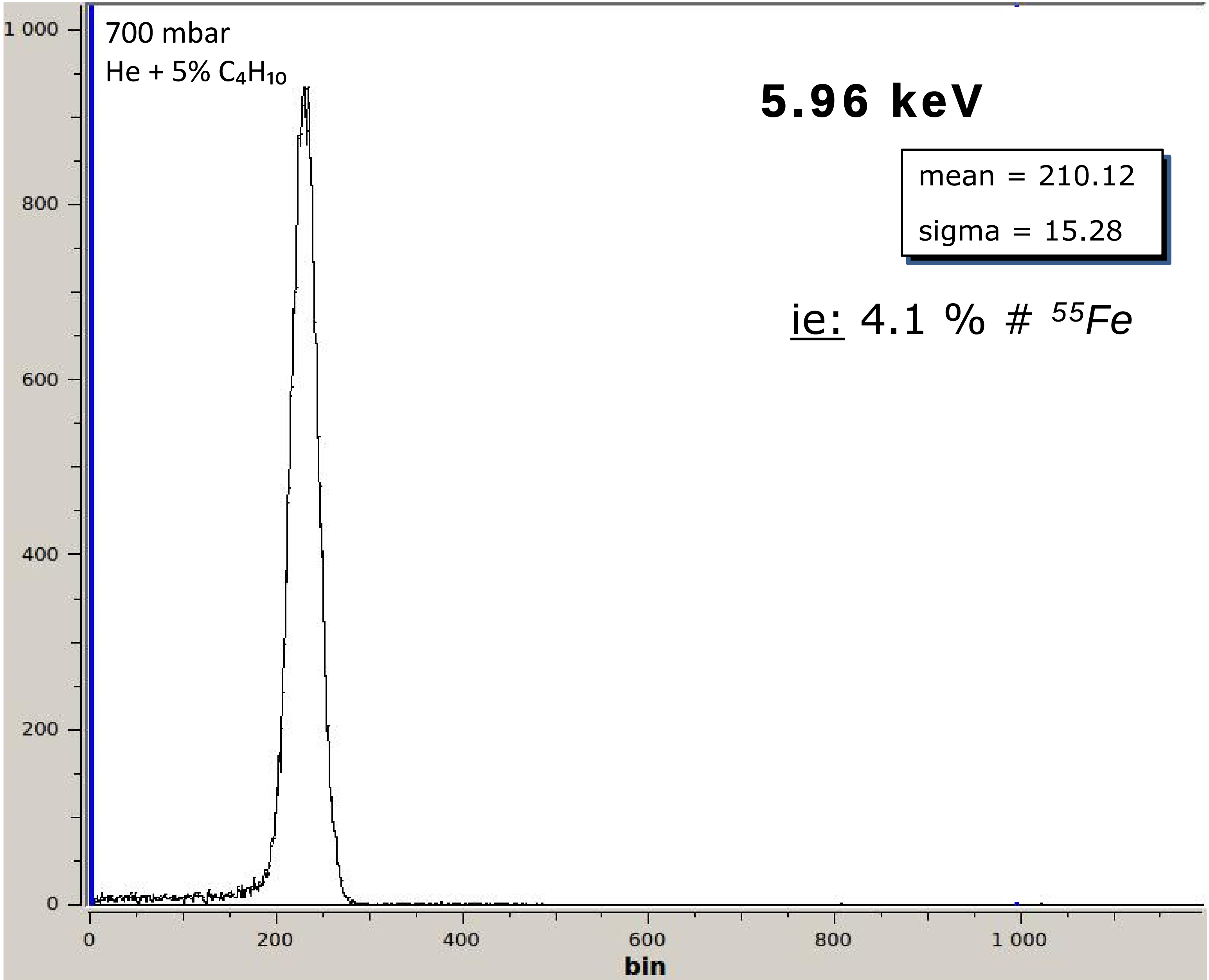
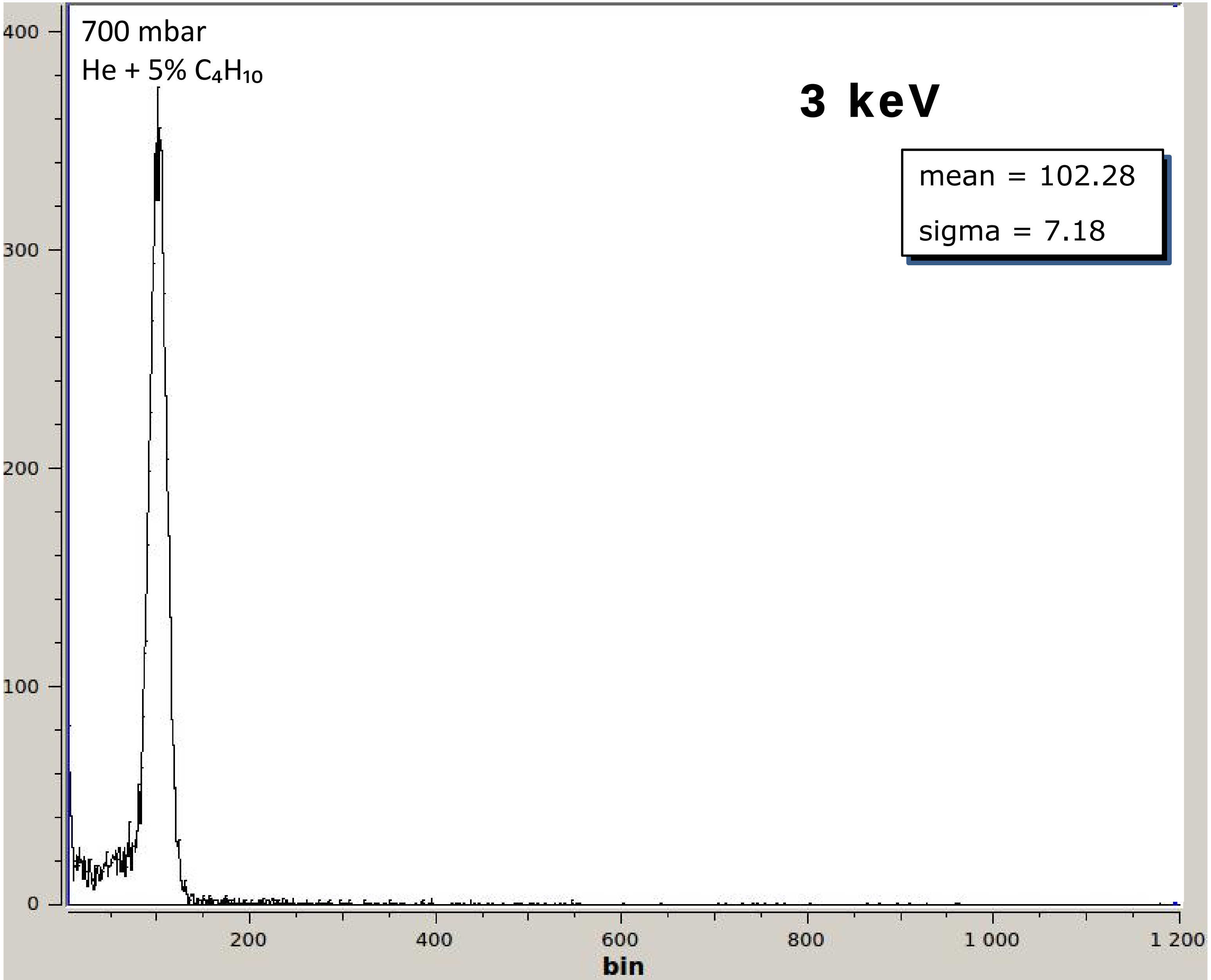


ie: 4.1 % # ^{55}Fe

Electrons Performance



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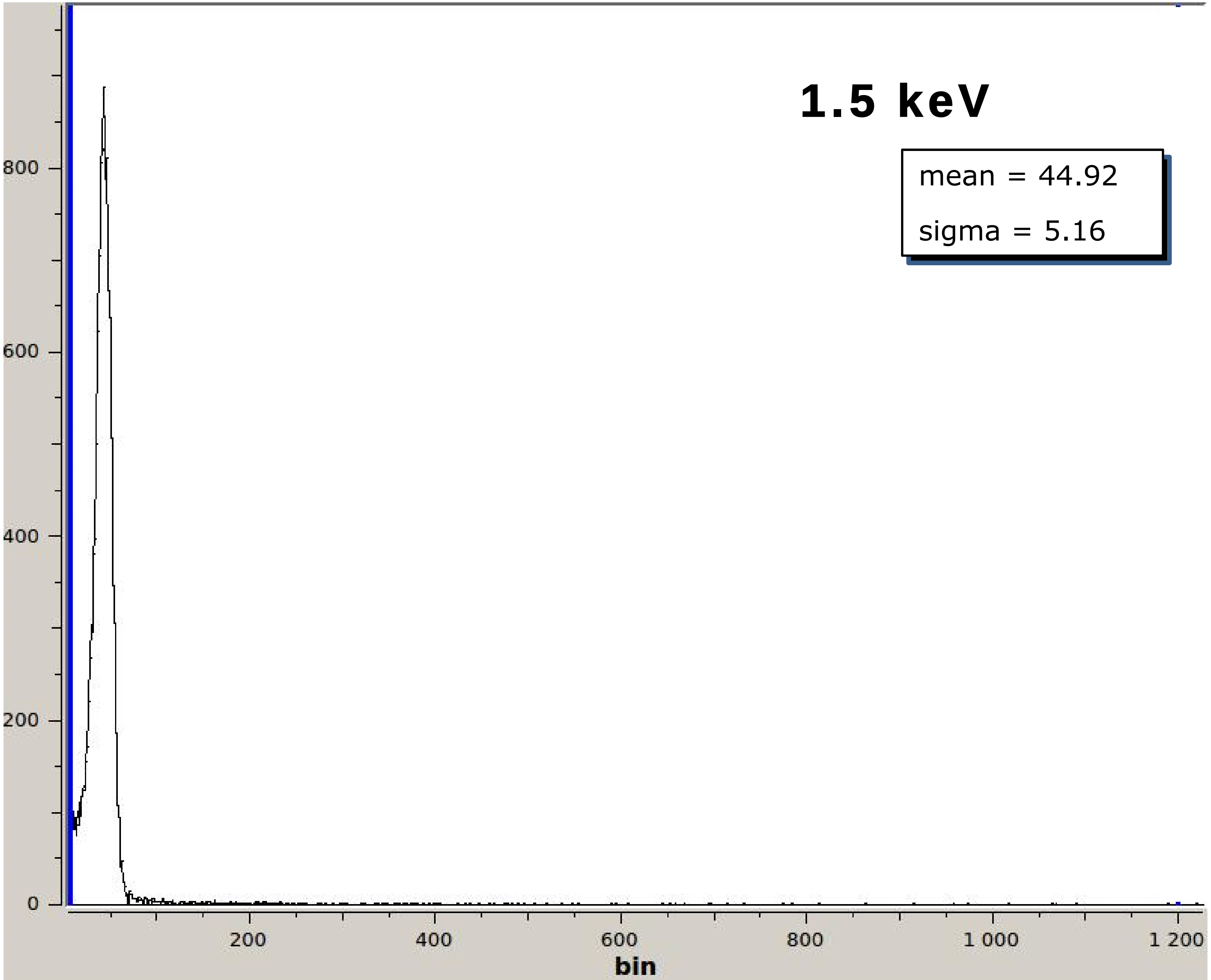

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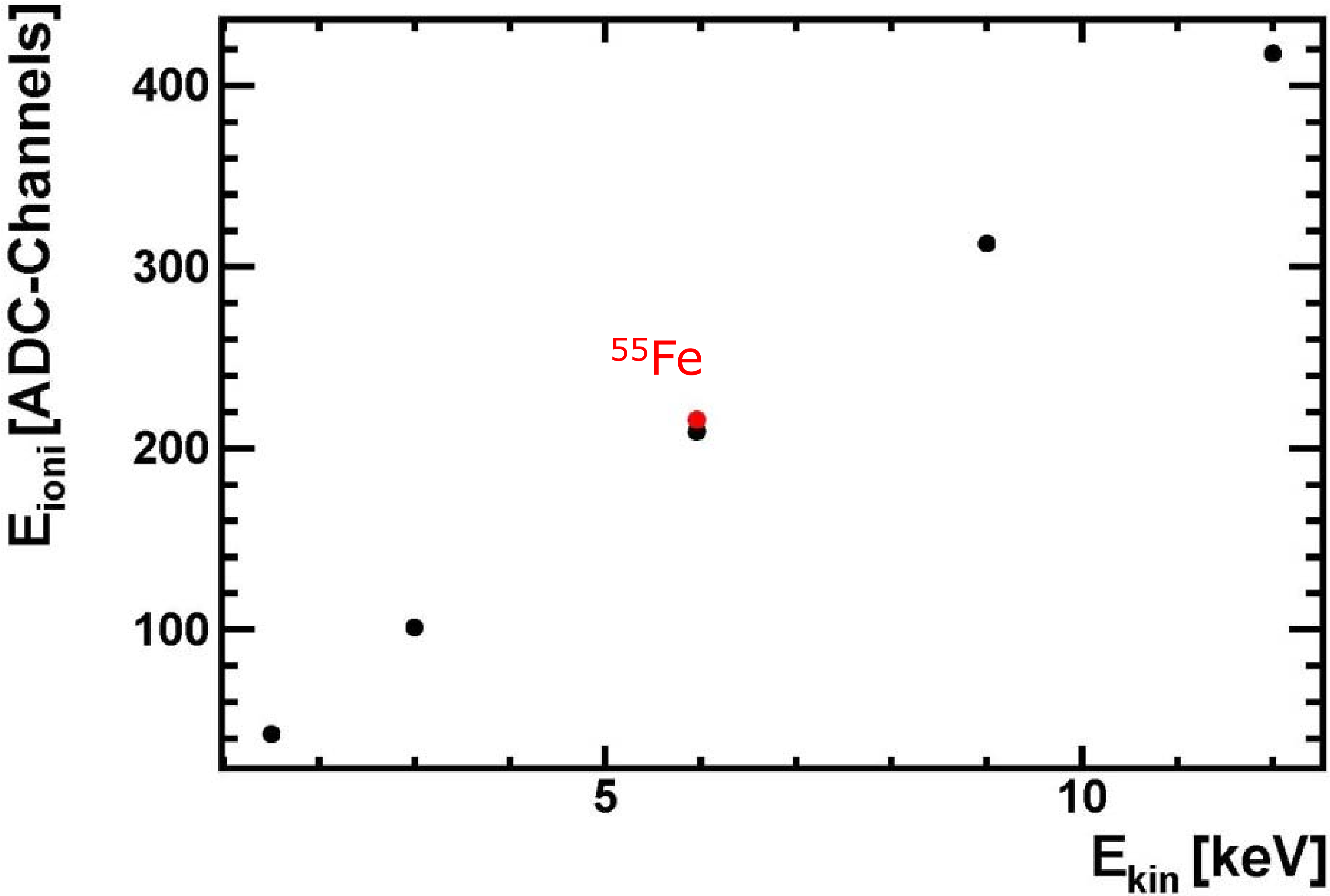
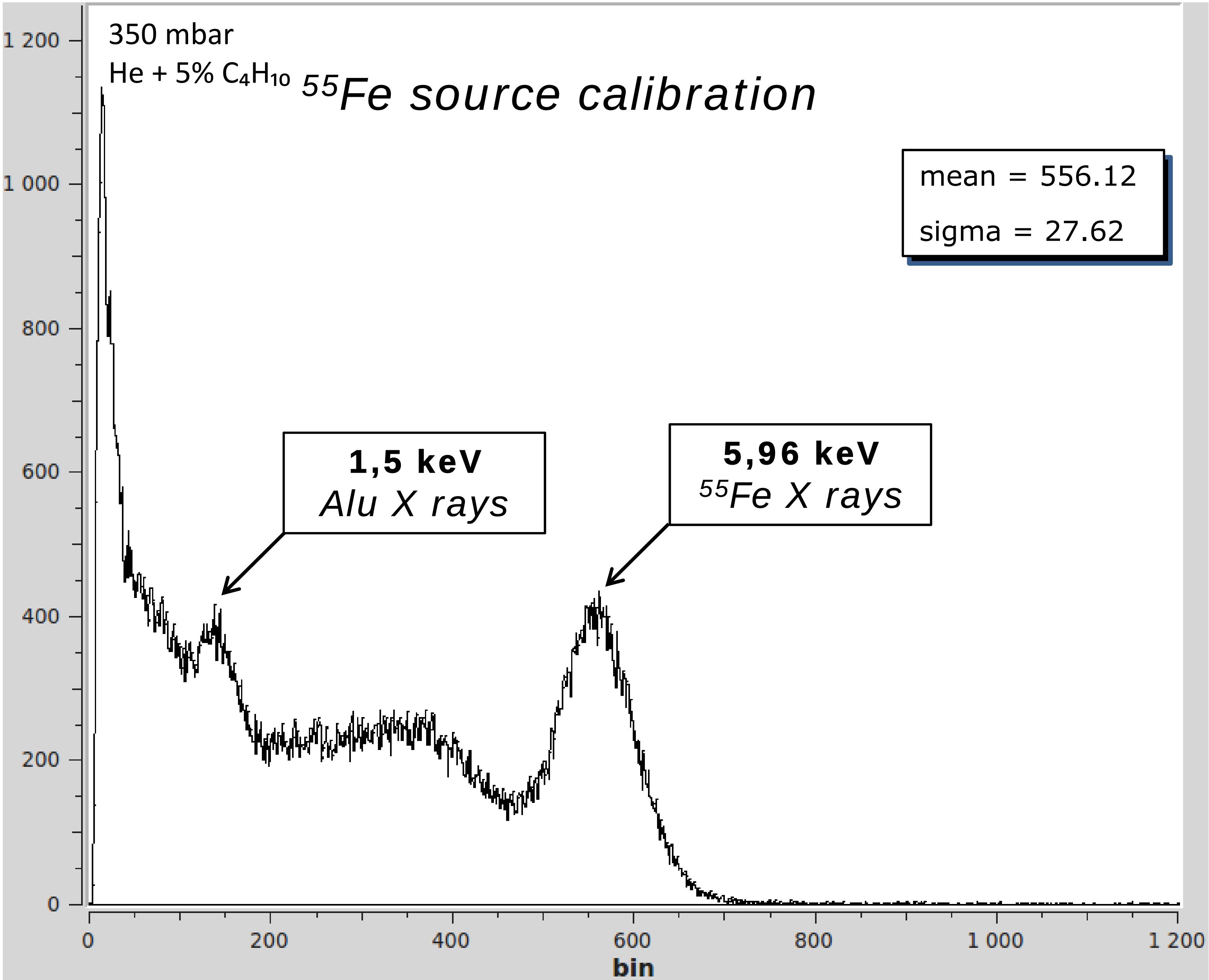


Ions Performance



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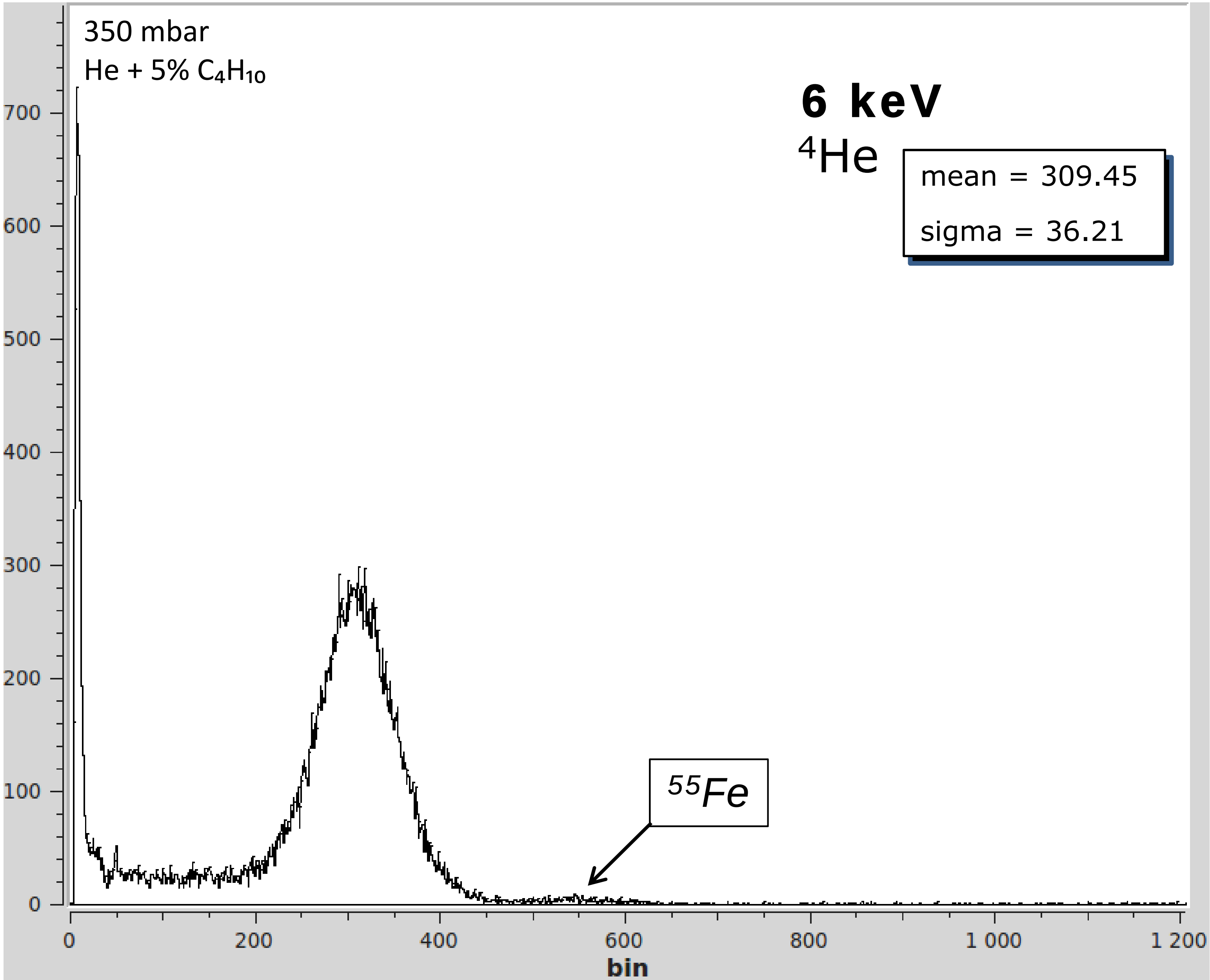

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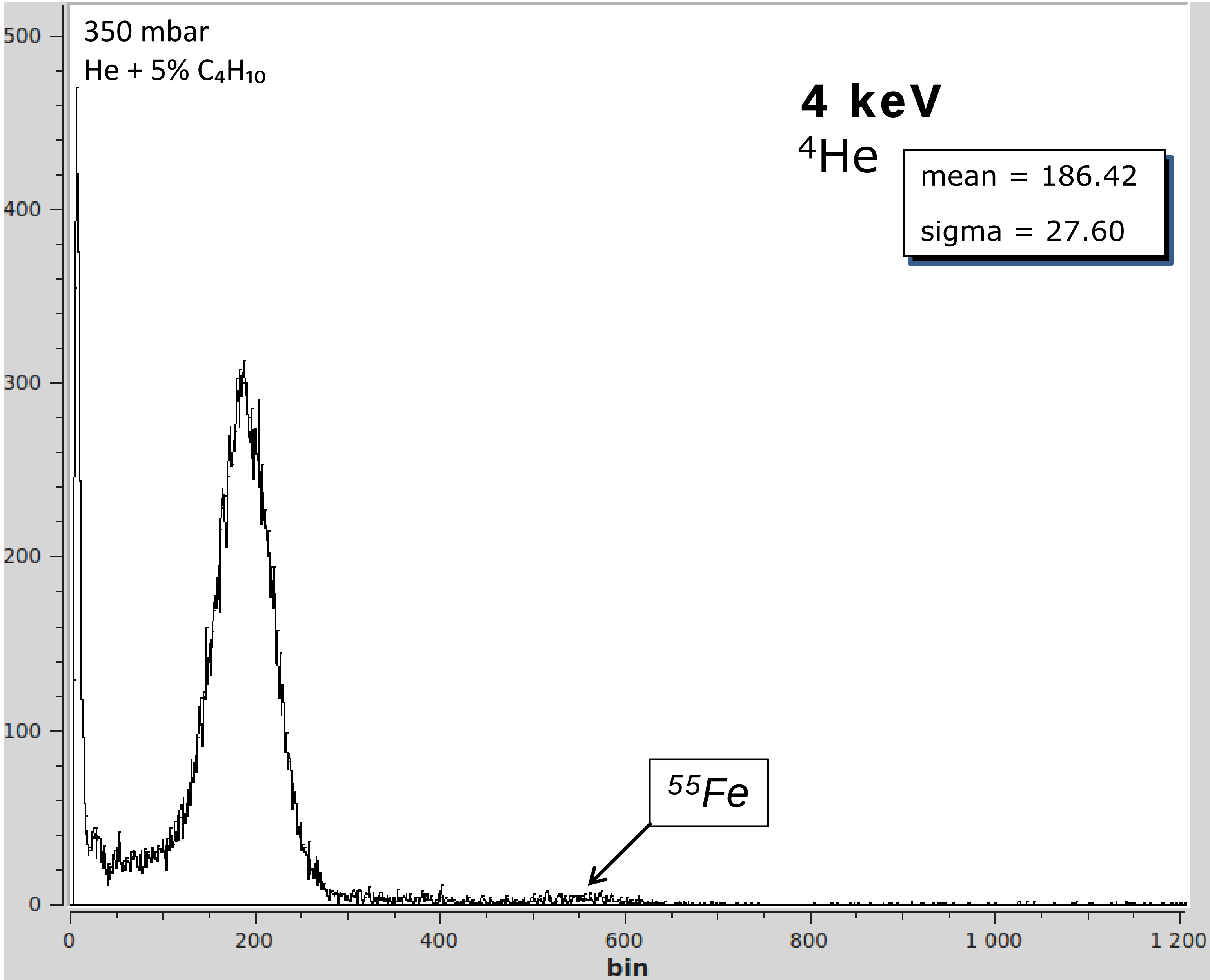

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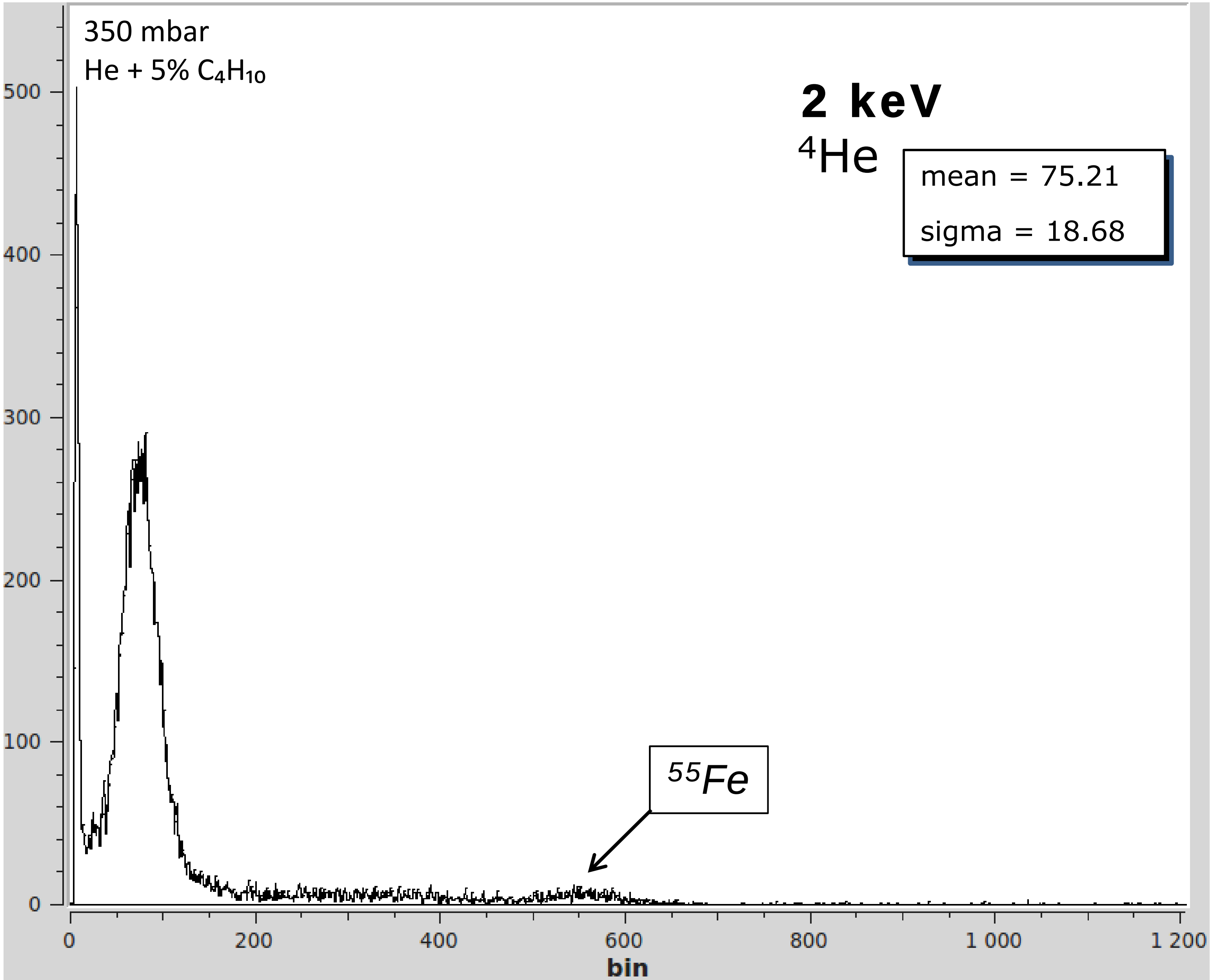

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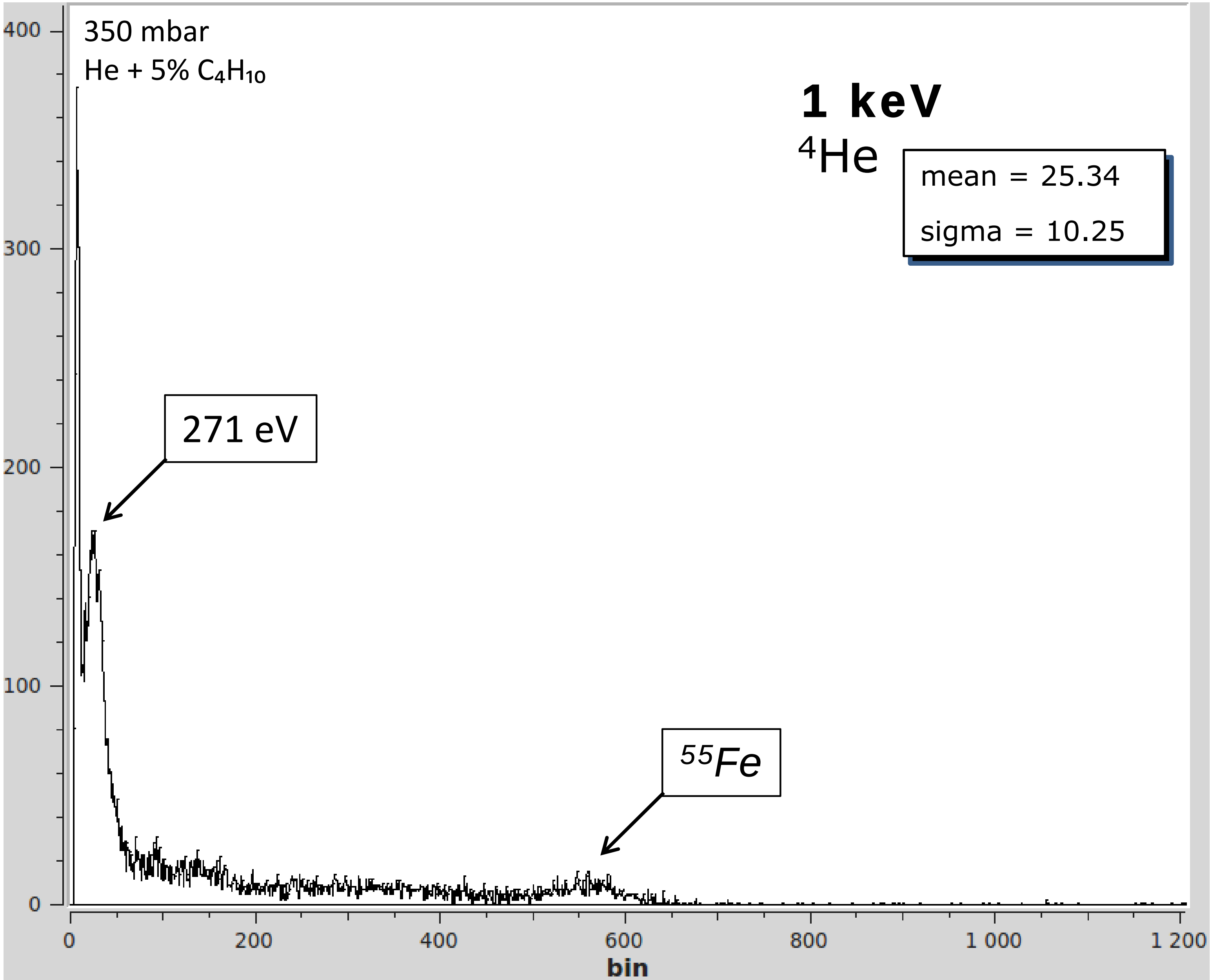

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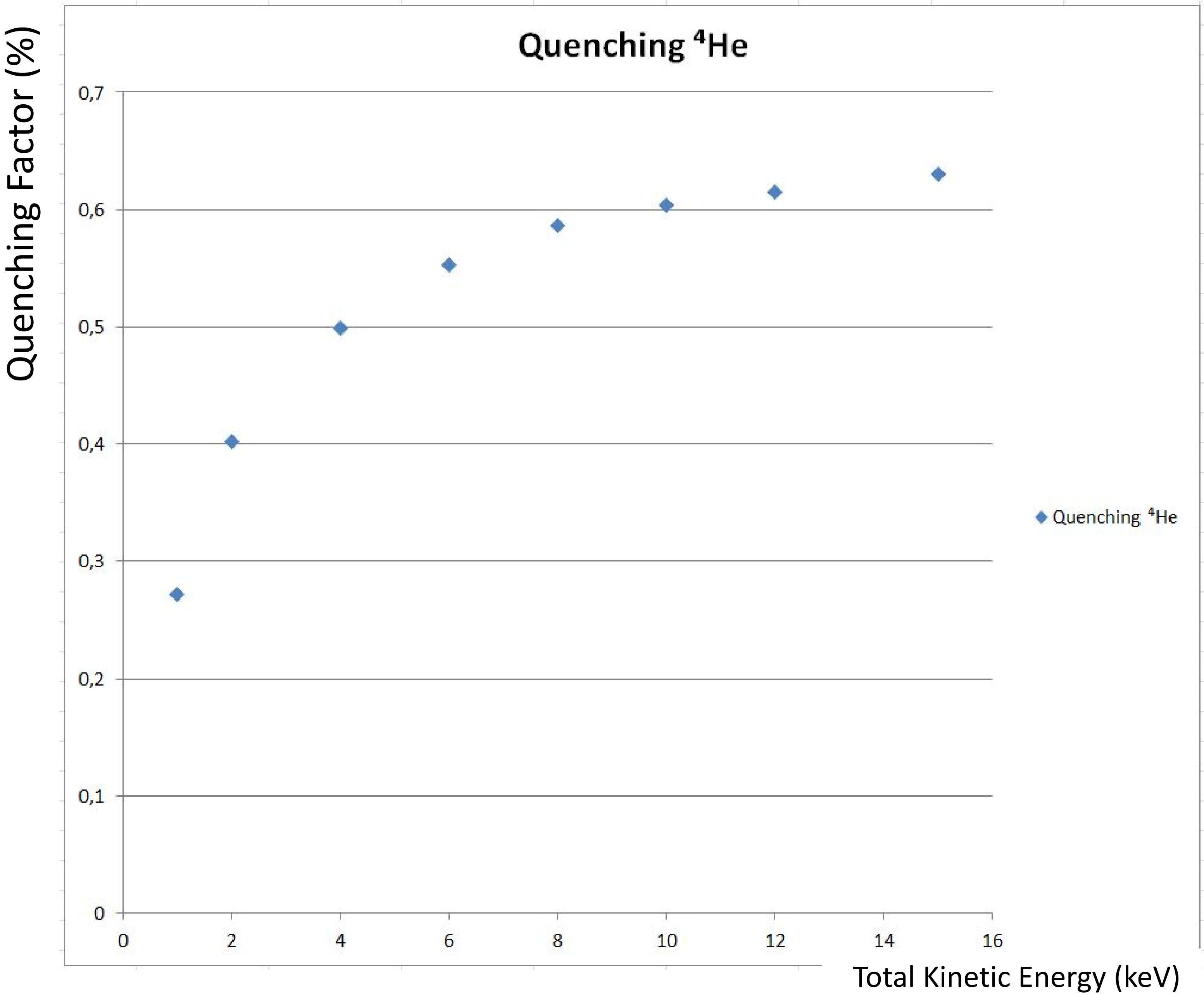
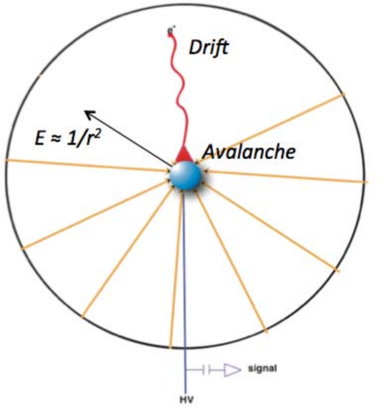
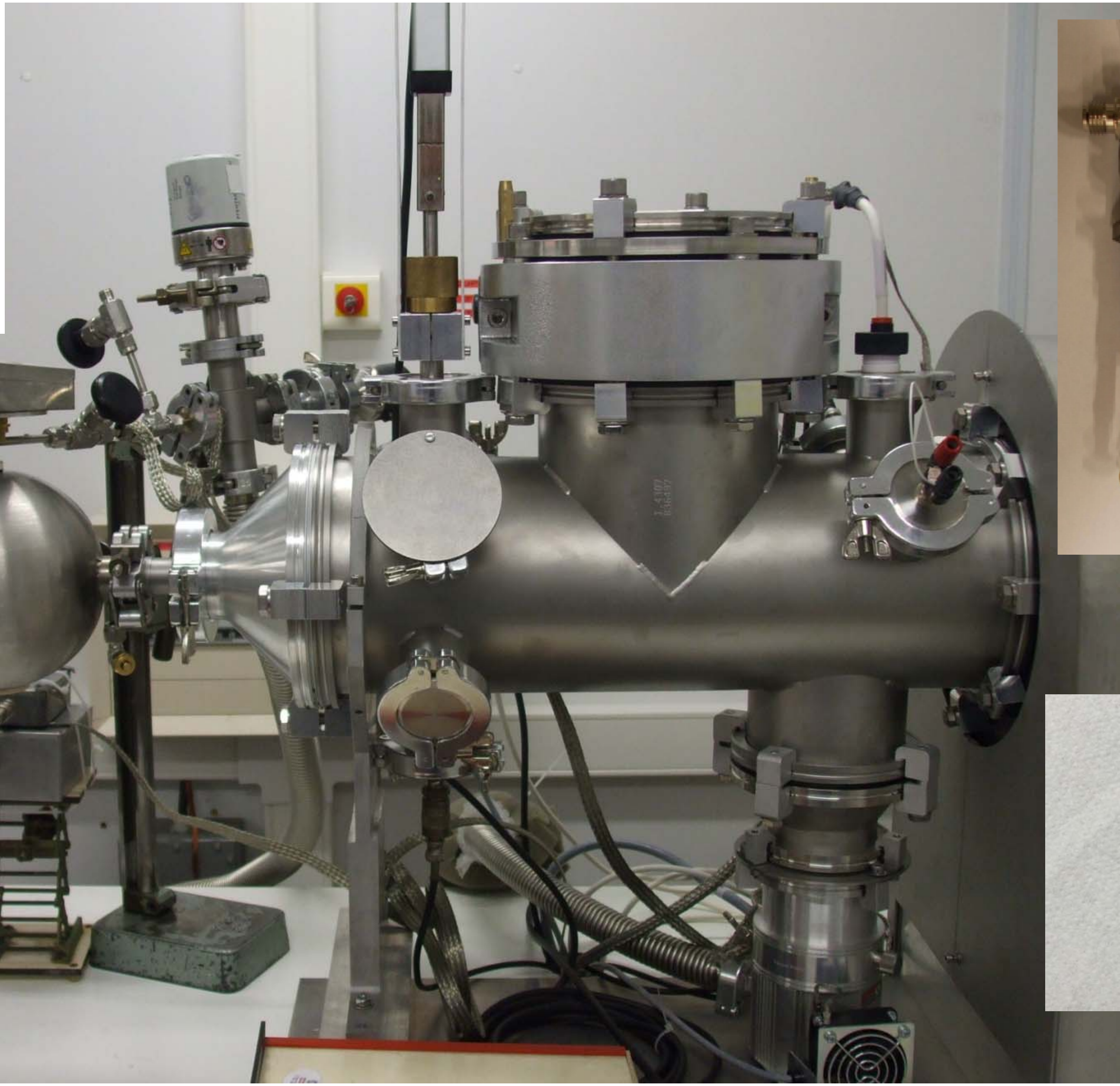


S15 Sphere Tests @Grenoble

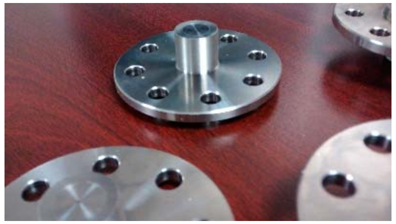
I.Giomataris – CEA Saclay

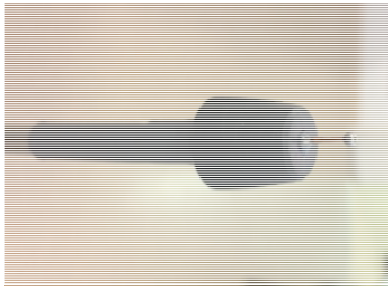


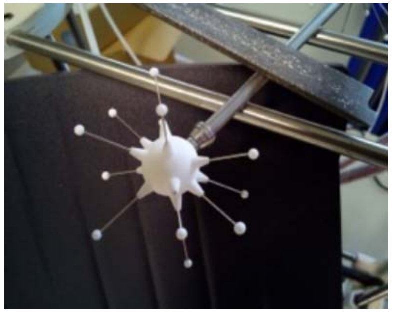


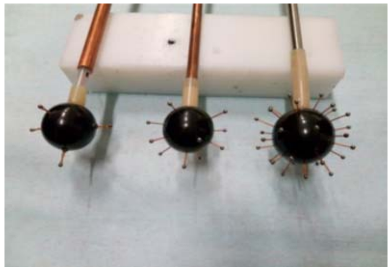
Sphere sensors tests @Grenoble

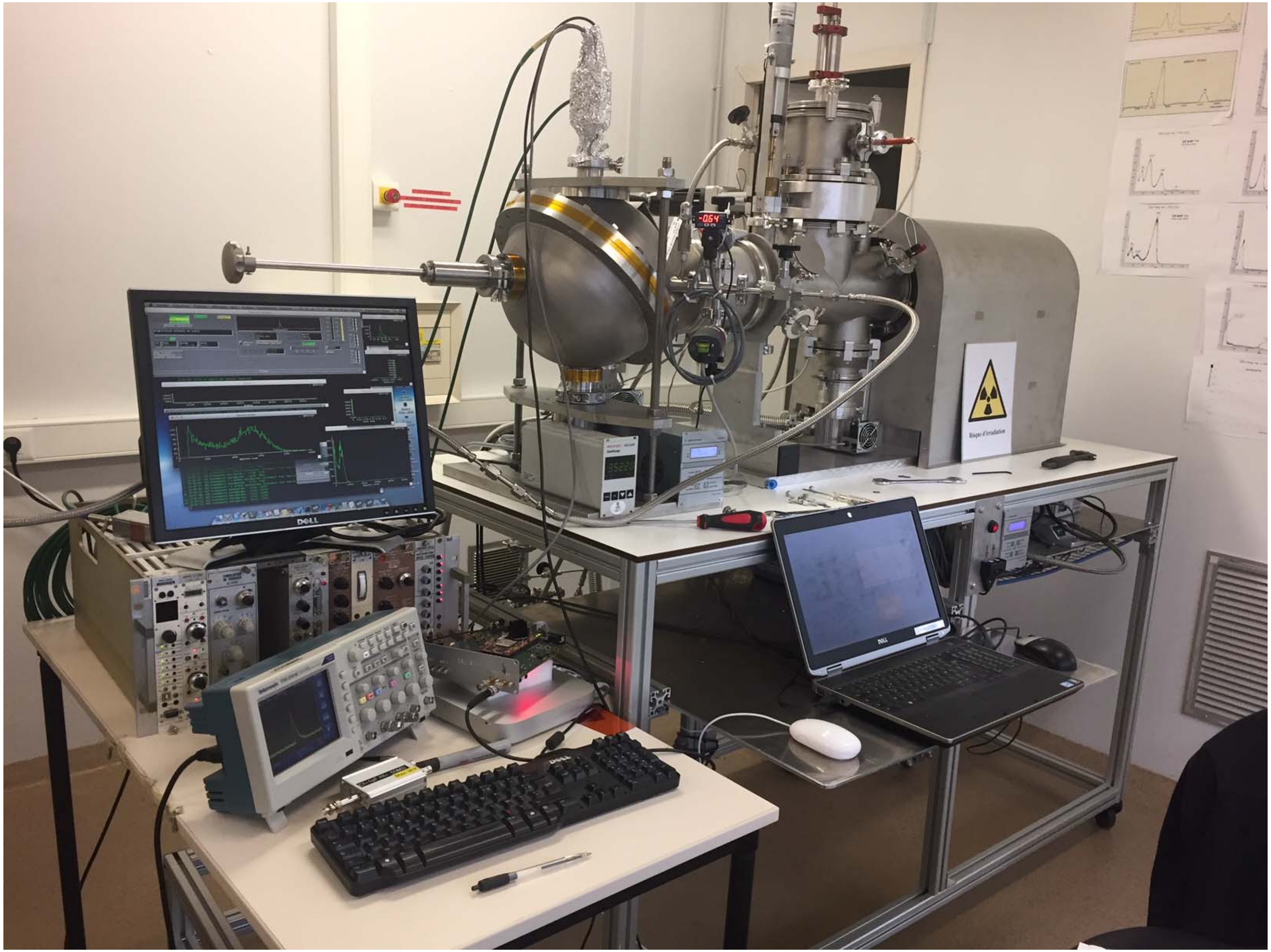
NEWS-G experiment - SNOLab











COMIMAC 2 @LMDN-IRSN

Laboratoire de métrologie et de dosimétrie du neutron

Conclusion

COMIMAC :

- Ion and electron beams up to 50 keV
- q/m selection of Ions with Wien filter
- Calibration with electrons
- Can be connected to "any" gaseous detector

Applications :

- Gas detector test facility (Gain stability, rate dependence *(1 kHz/μm^2)*
- Energy calibration with any recoil (proton, alpha, fluorine…)
- Ionization Quenching Factor measurement
- Gas monitoring
- …

Backup

Electrons Performance

Set up :

- Electrons extracted from Nitrogen plasma in the source
- Gas : He + 5% C_4H_{10}
- Pressure : 700 mbar
- µmegas : 256 µm
- Drift distance : 60 mm
- Drift E field : 108 V/cm
- Gain : 471 V *(Grid : 650 V, Anode : 1 121 V)*
- Energies : 1.5 – 3 - 5.96 – 9 - 12 keV

Ions Performance

Set up :

- Ions : ^{4}He
- Gas : He + 5% C_4H_{10}
- Pressure : 350 mbar
- µmegas : 256 µm
- Drift distance : 60 mm
- Drift E field : 166 V/cm
- Gain : 460 V *(Grid : 1000 V, Anode : 1 460 V)*
- Energies : 1 – 2 - 4 – 6 – 8 - 10 – 12 - 15 keV