COMIMAC

A low energy table top ion / electron facility for gaseous detector calibration and Ionization Quenching Factor measurement

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Laboratoire de Physique Subatomique et de Cosmologie

Outline

- Introduction
- General description of COMIMAC
- Electron performances
- Ion performances
- The IRSN-LMDN Facility
- CEA-Saclay sphere@Grenoble *(Calibration and IQF measurements)*
- Conclusion

Introduction

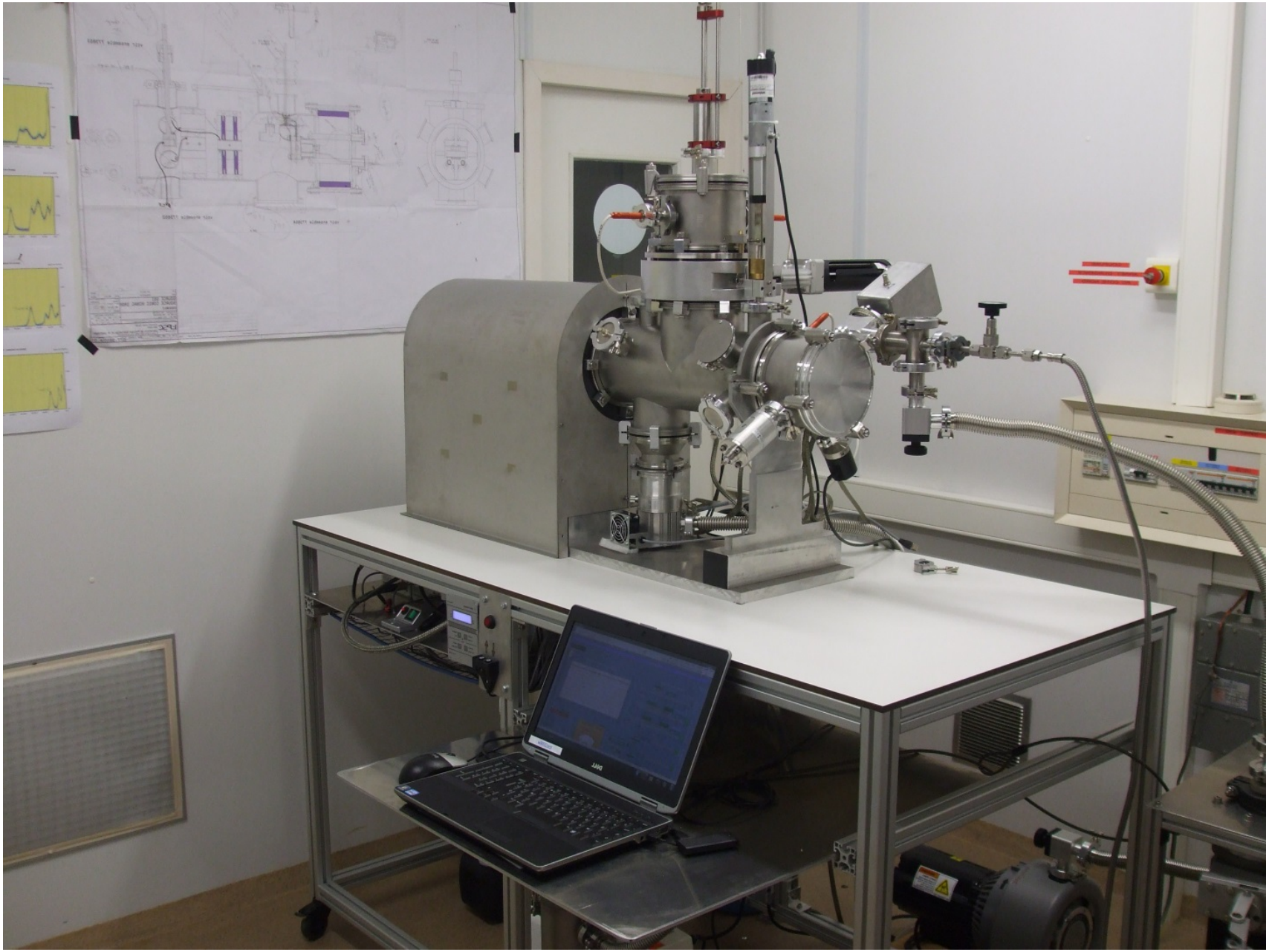
- MIMAC : MIcro-tpc MAtrix of Chambers *(pixelised micromegas coupled with self triggered fast electronic)*
- Project Aim: Directional detection of non baryonic Dark Matter
- Measures energy and direction of few keV nuclear recoils produced by elastic scattering of WIMPs

  ⟹ only a certain fraction of the recoil energy is deposited in the ionization chanel -> Ionization Quenching

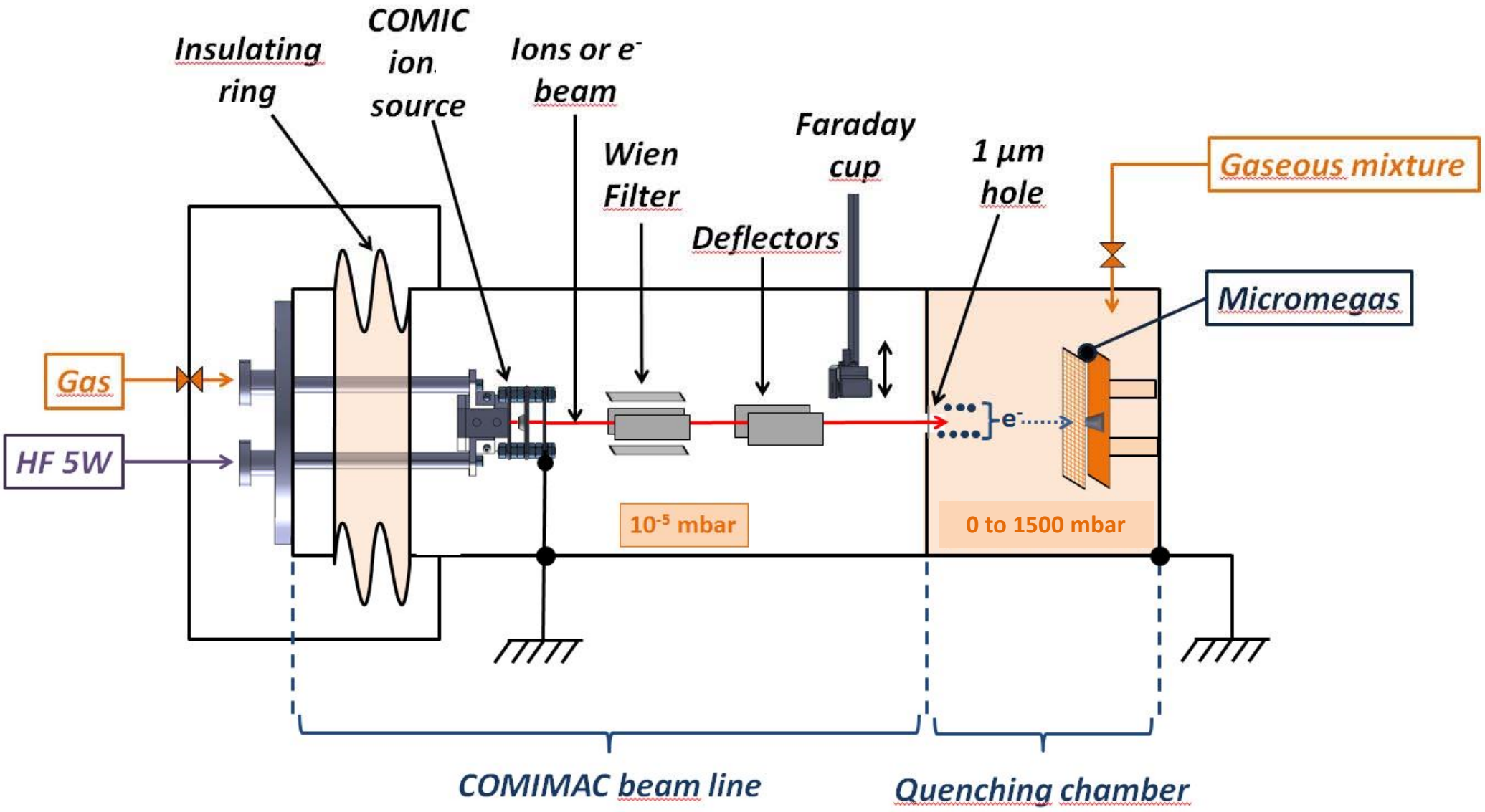
- Ionization Quenching Factor (IQF): $\frac{\text{Measured ionization energy}}{\text{Initial kinetic energy}}$
- Calibration : for low pressure gases, using X-rays sources is inefficient due to gas transparency

  ⟹ We need a facility able to produce:
  - Ions for IQF measurements
  - Electrons for calibration
  - ”Cost-effective” & ”Transportable”

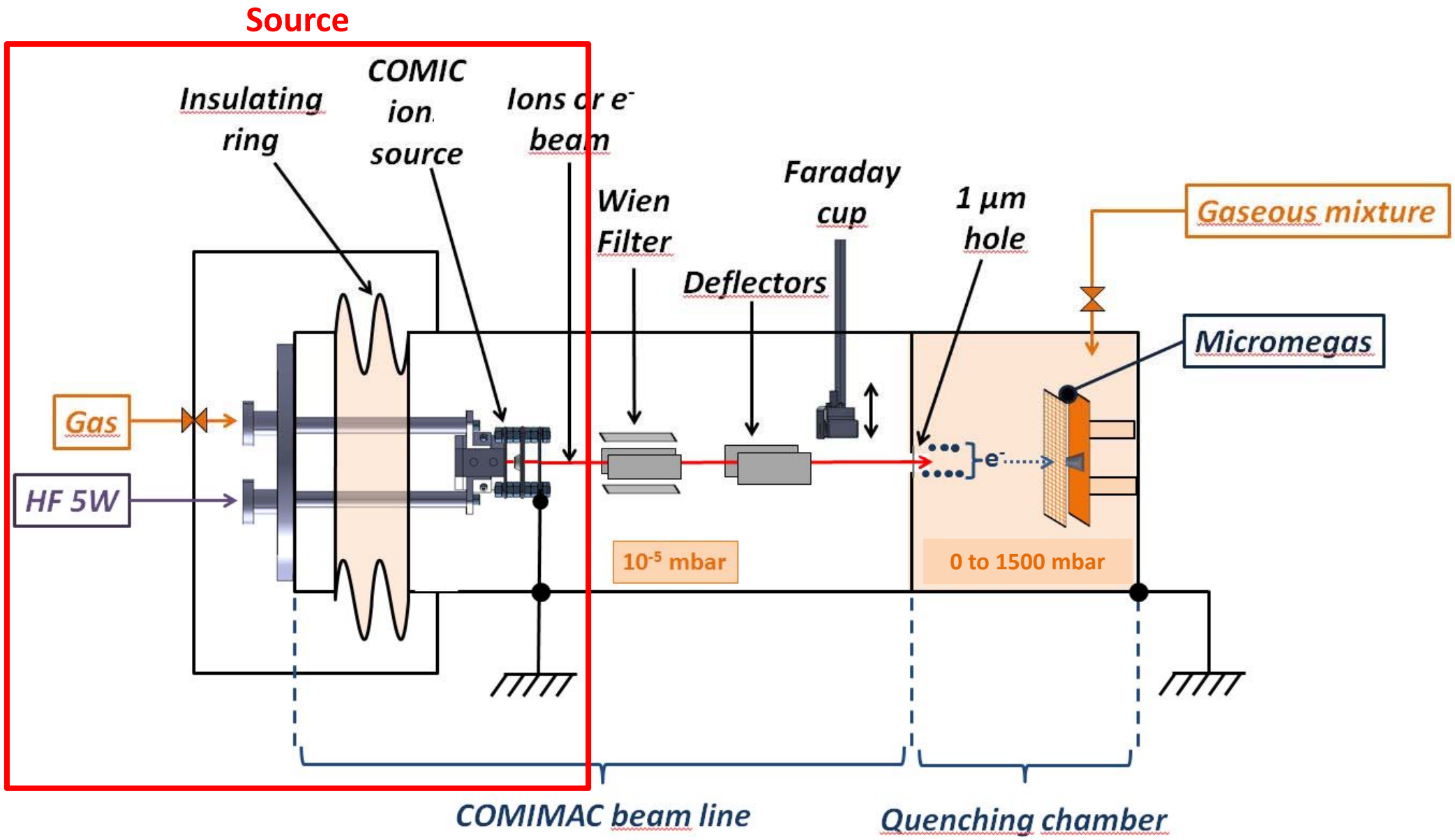
COMIMAC



COMIMAC


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

COMIMAC


Source
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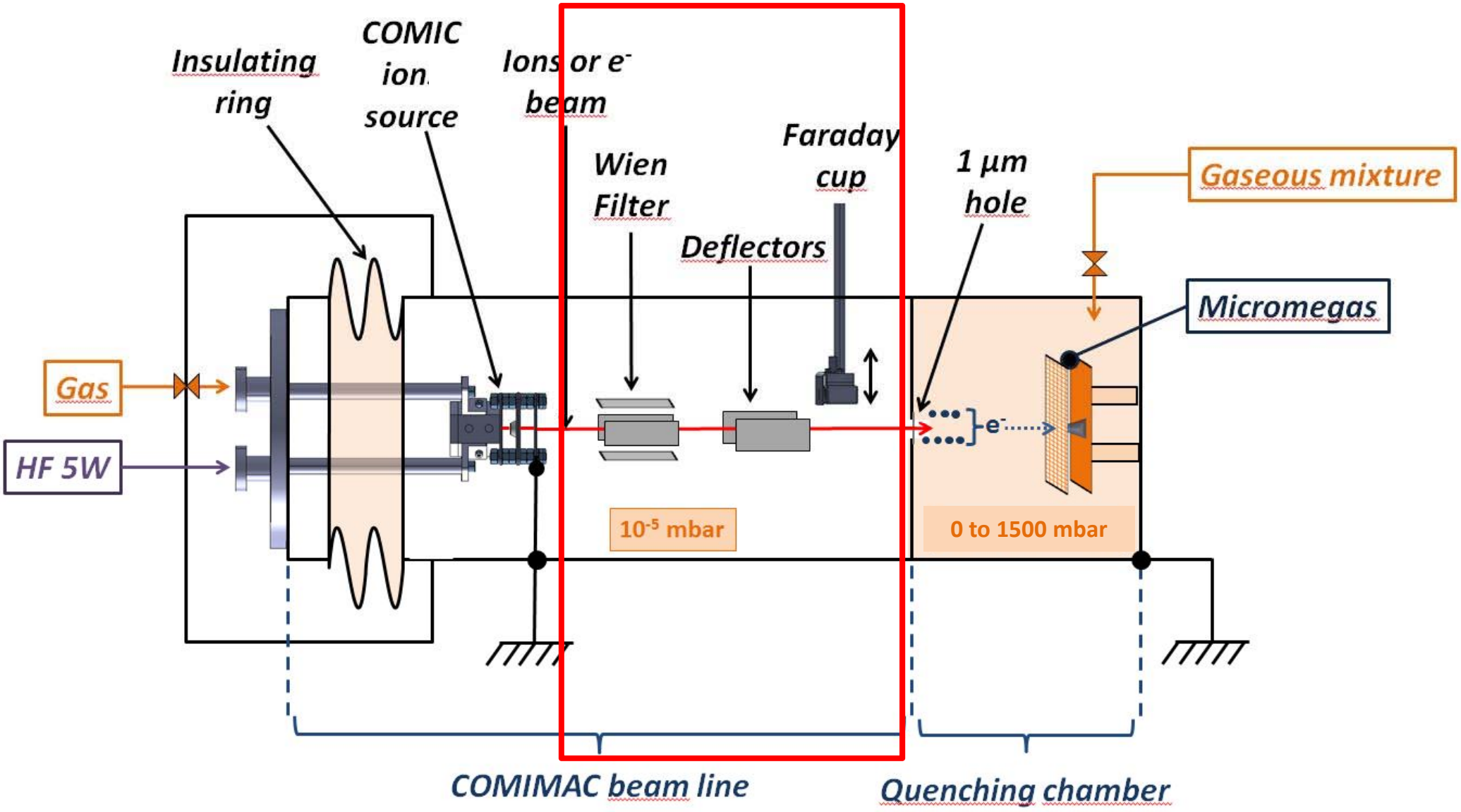
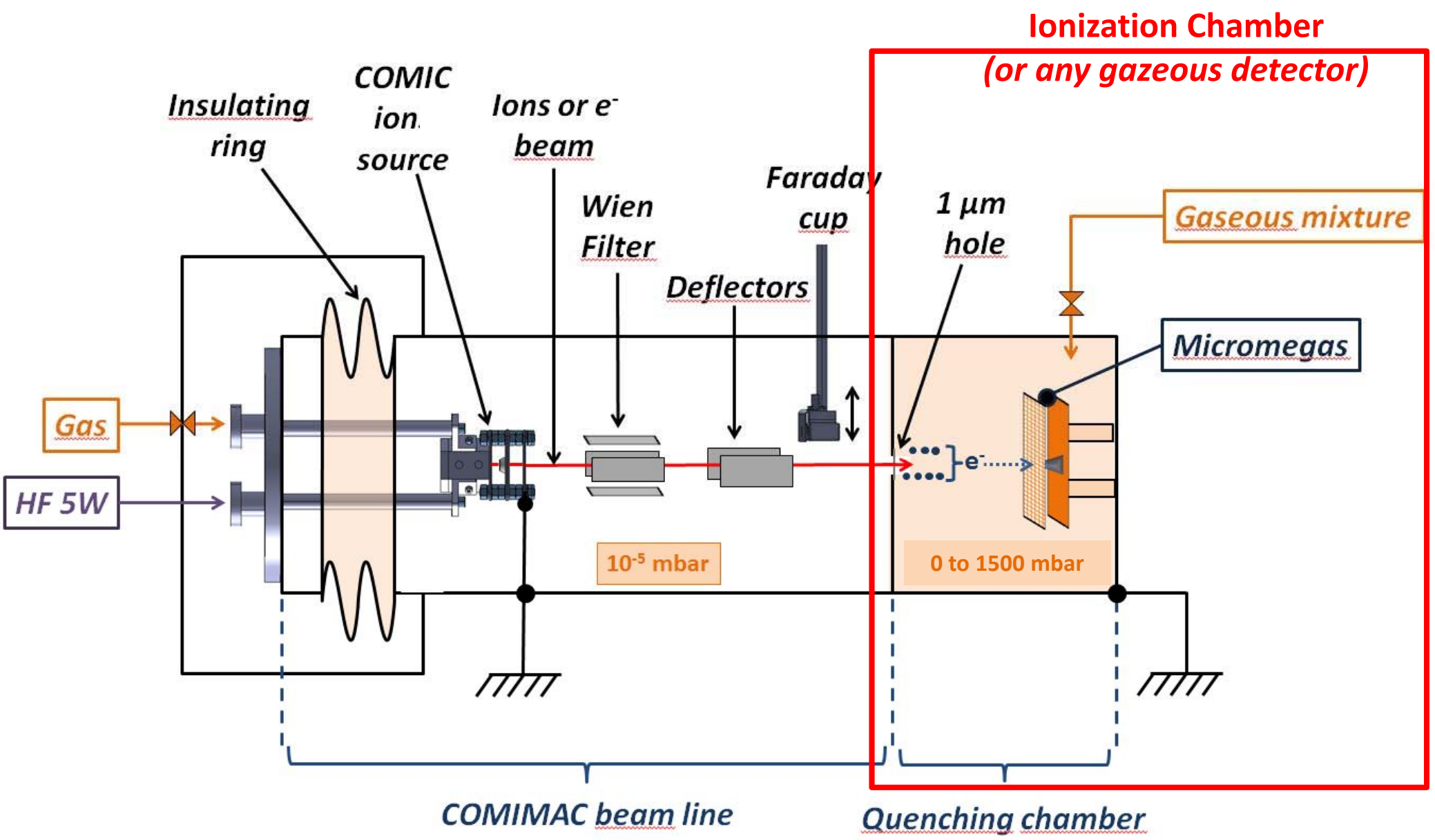
COMIMAC

Beam Monitoring



COMIMAC


Ionization Chamber
(or any gazeous detector)
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Deflectors
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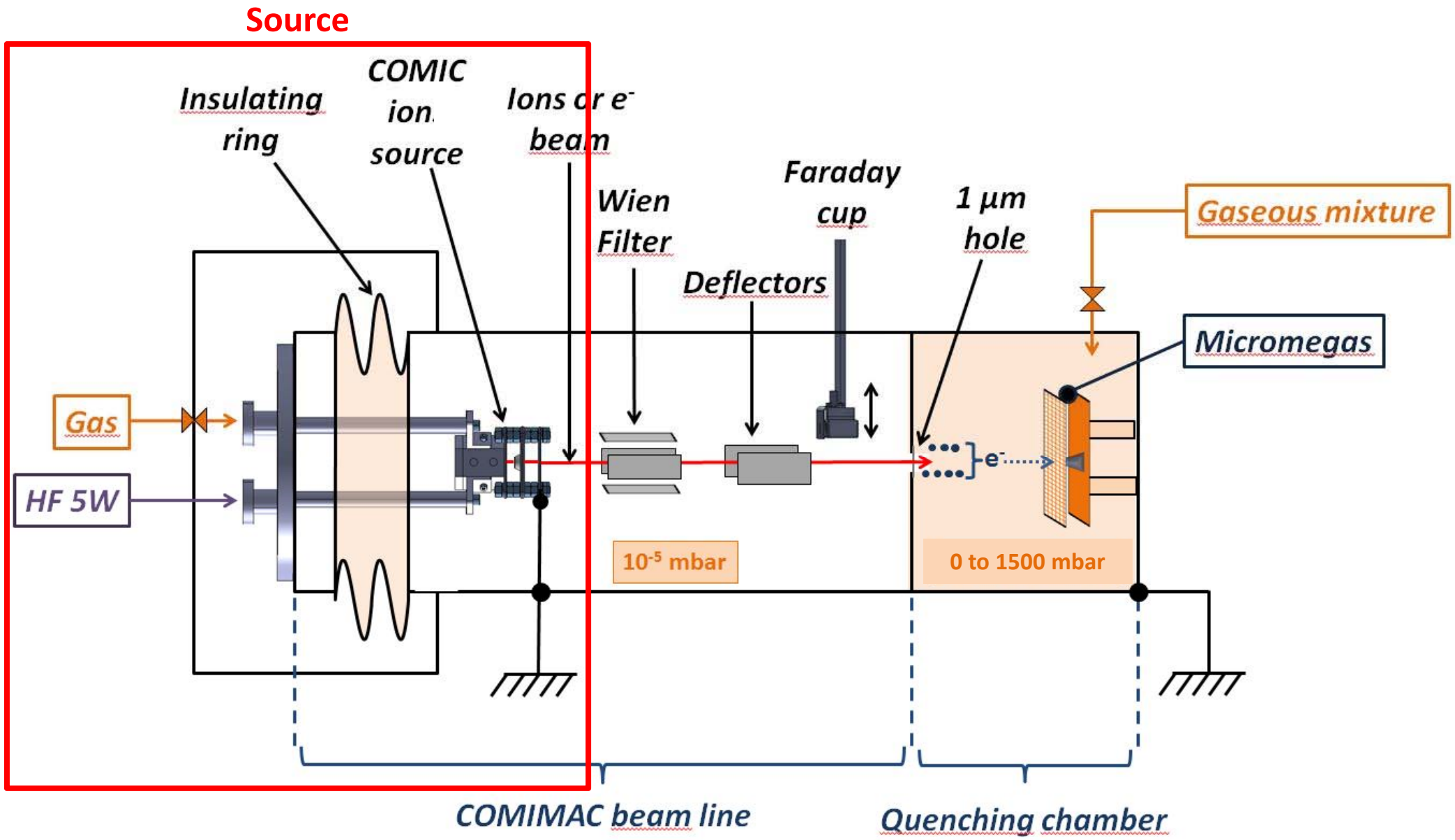
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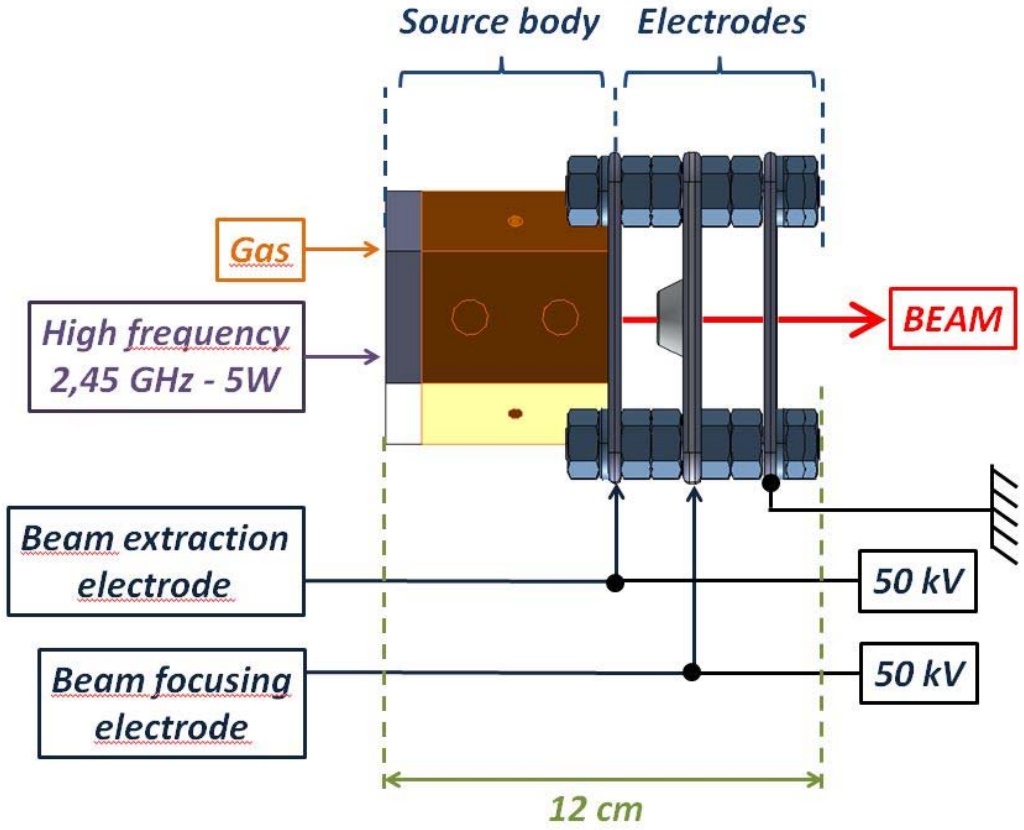
COMIMAC beam line
Quenching chamber

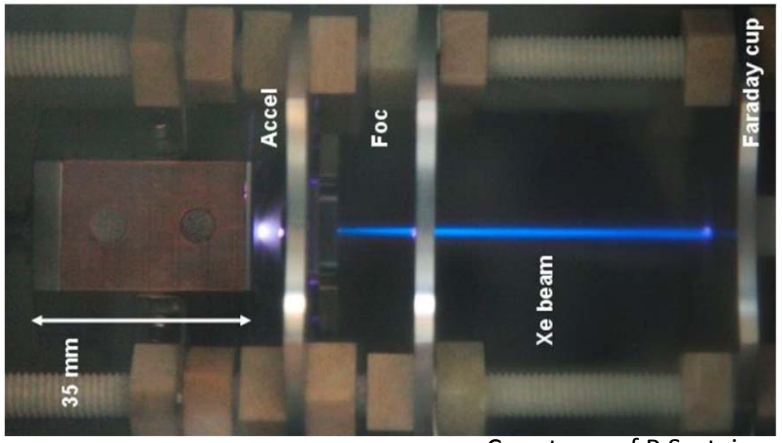
Highly Miniaturized Source

COMIC *"**CO**mpact **Mi**crowave **C**oaxial"* is an highly optimized and miniaturized **E**lectron **C**yclotron **R**esonance (ECR) source developed at LPSC by SSI Group. (*Patent: WO2010043831(A1)–2008*)

The current density can reached 10 mA/cm².



Kinetic energy = Extraction Voltage



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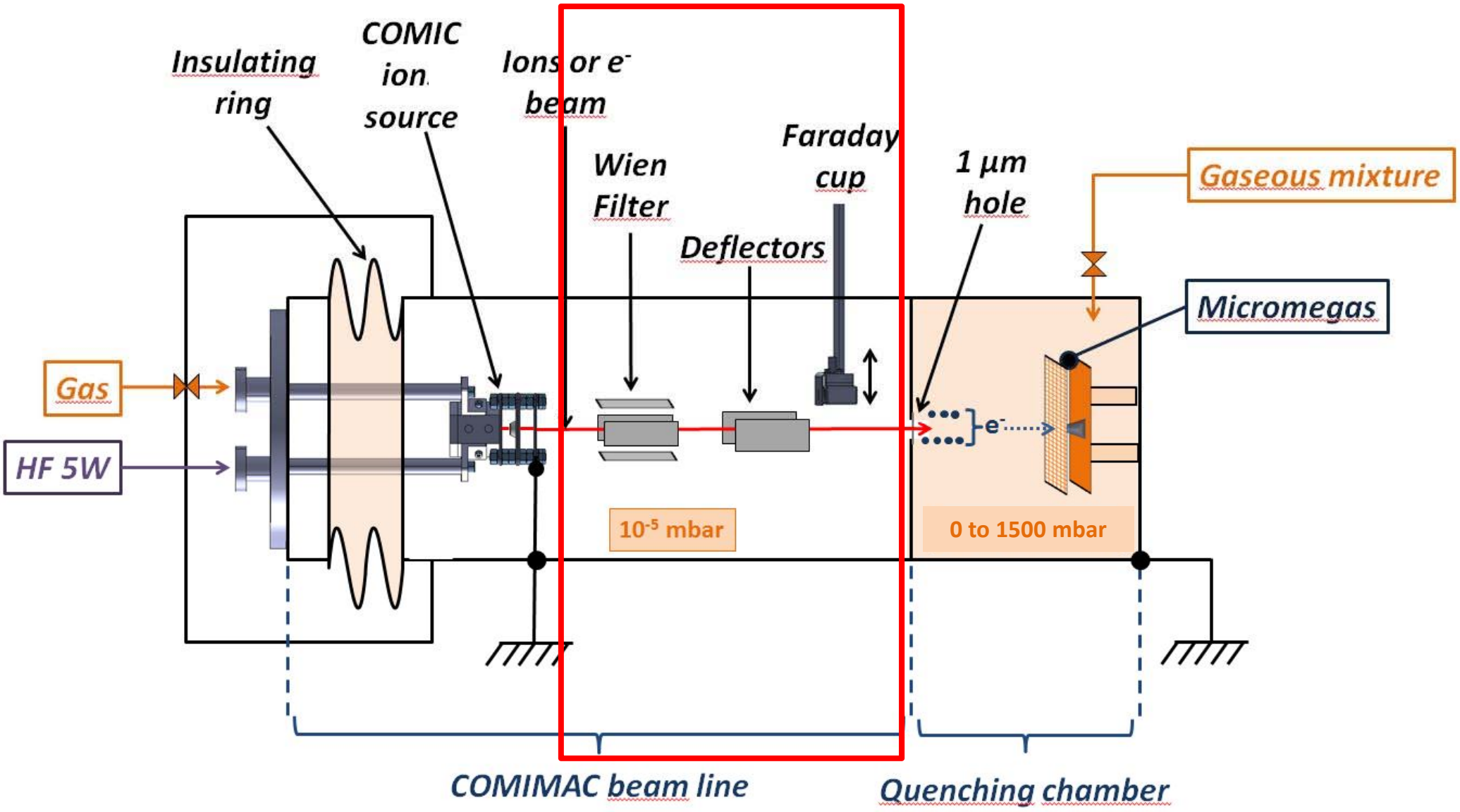
COMIMAC

Beam Monitoring



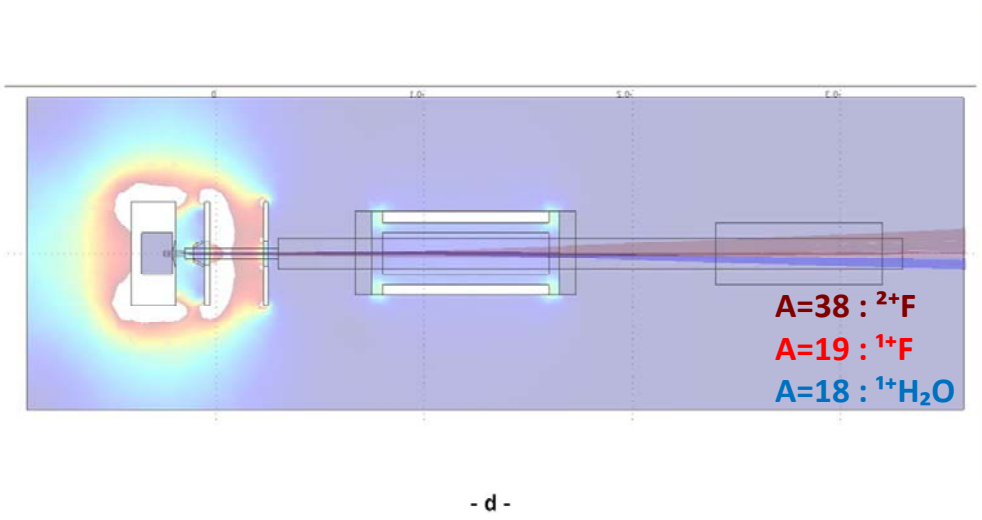
Wien Filter

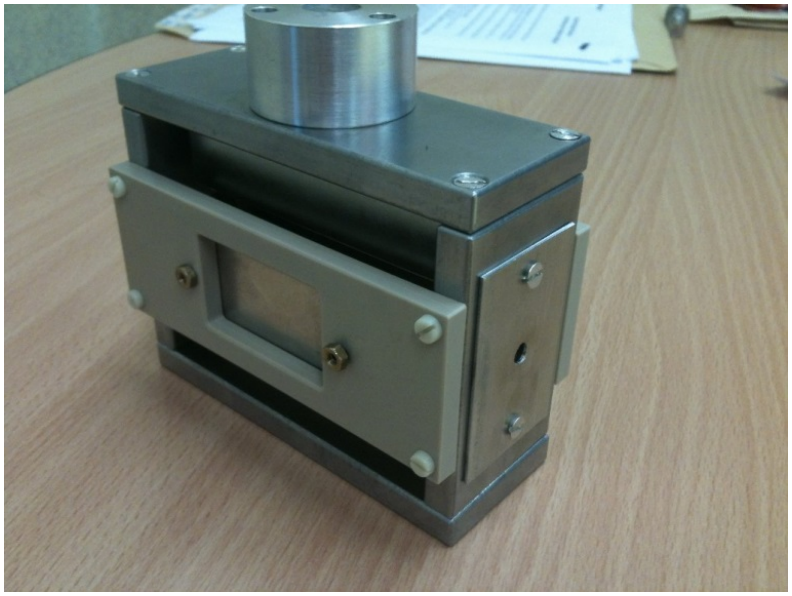
Aim:

- Make a q/m selection of ions

Combination of:

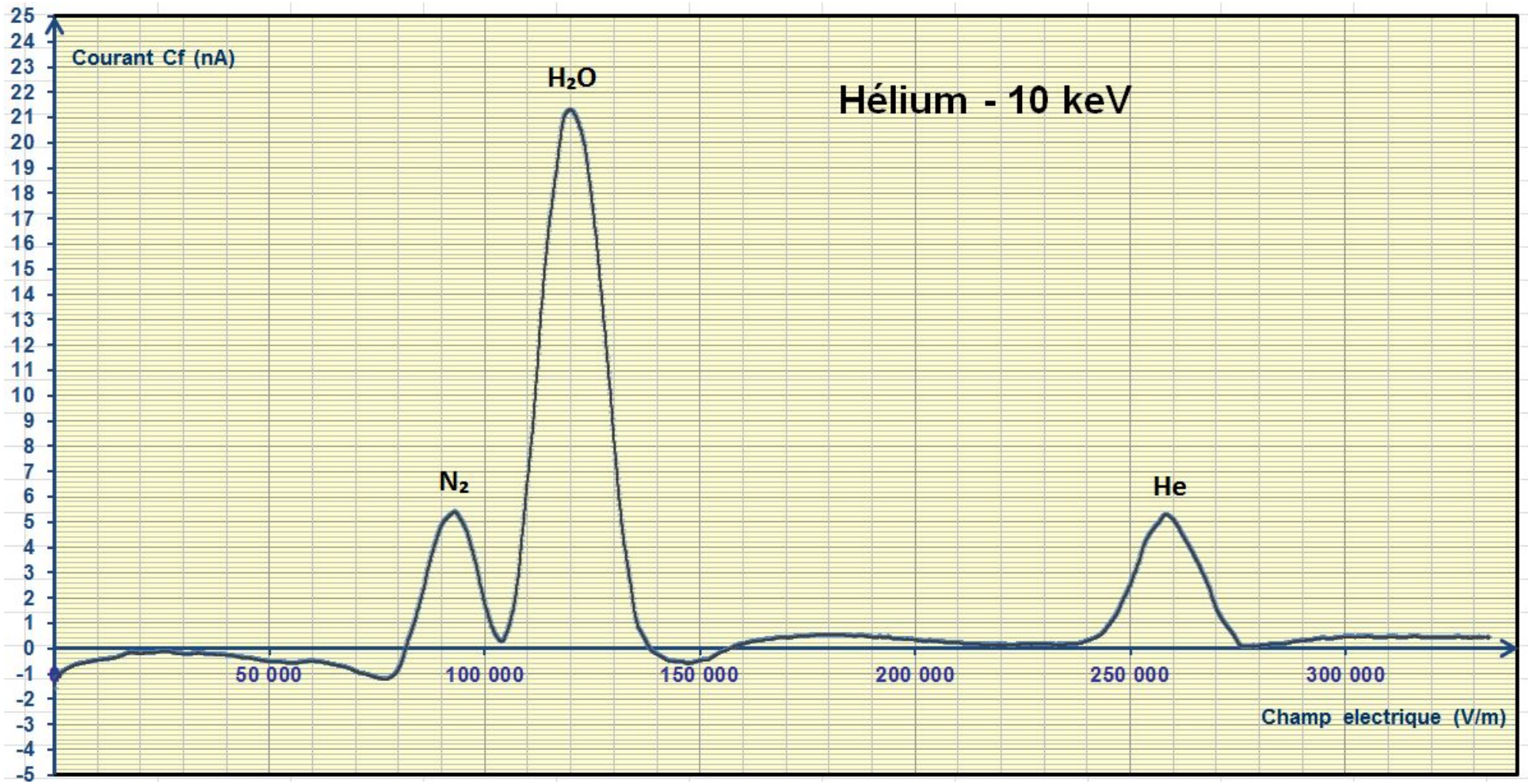
- 0.36 Tesla vertical magnetic field produced by 2 permanent magnets
- 3.3 kV/cm horizontal electric field





Wien Filter

Wien filter spectrum on the faraday cup



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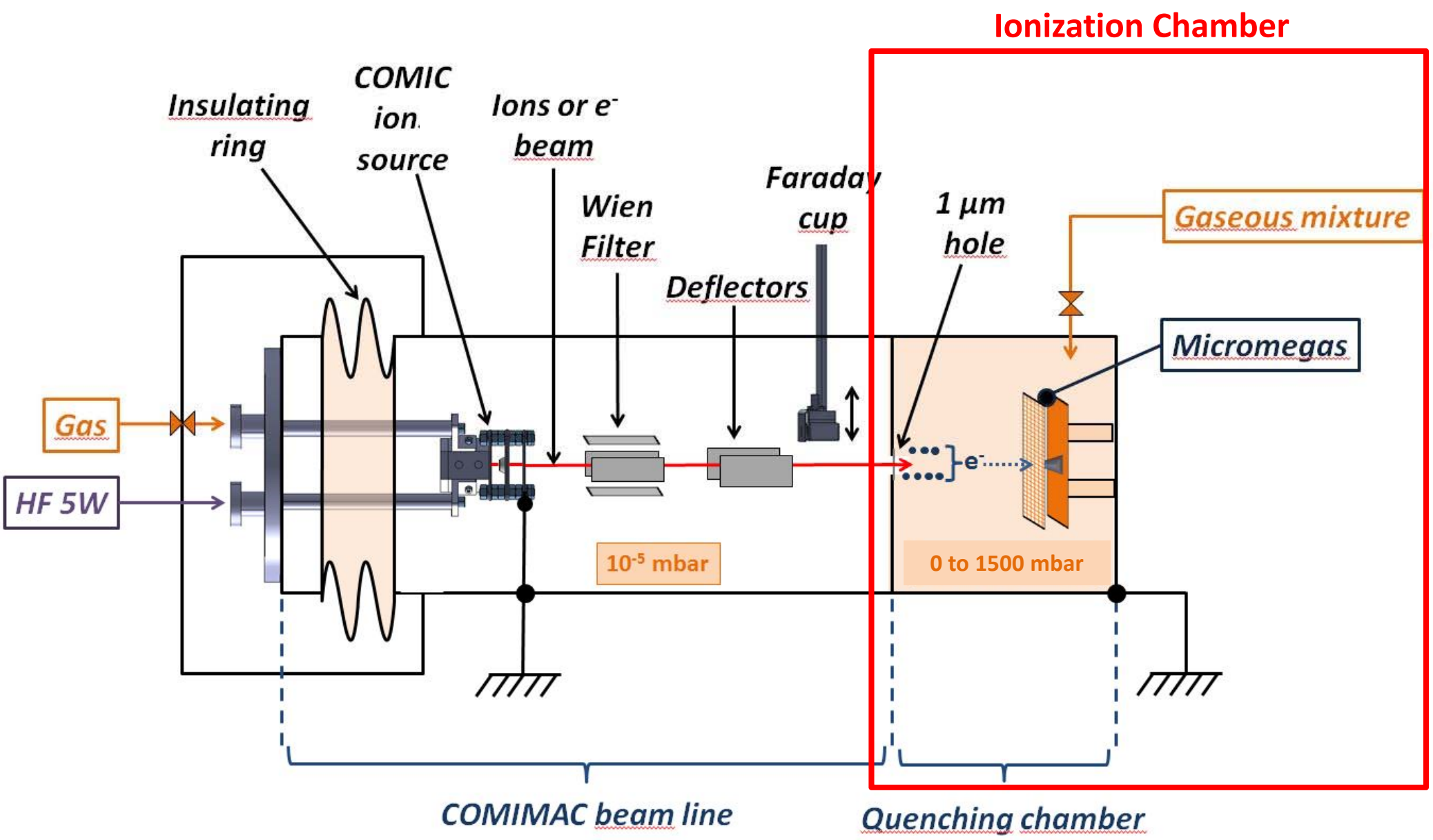
Ionization Chamber
Insulating ring
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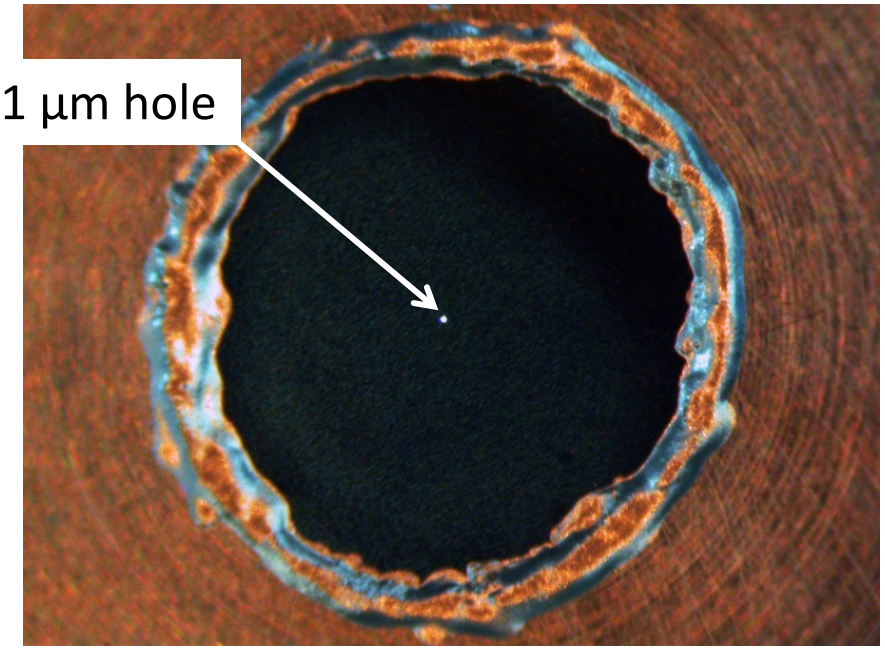
Ions or e- beam
Wien Filter
Faraday cup
Deflectors
1 µm hole
Gaseous mixture
Micromegas
Gas
HF 5W
e-
10-5 mbar
0 to 1500 mbar
COMIMAC beam line
Quenching chamber

Chamber Interface

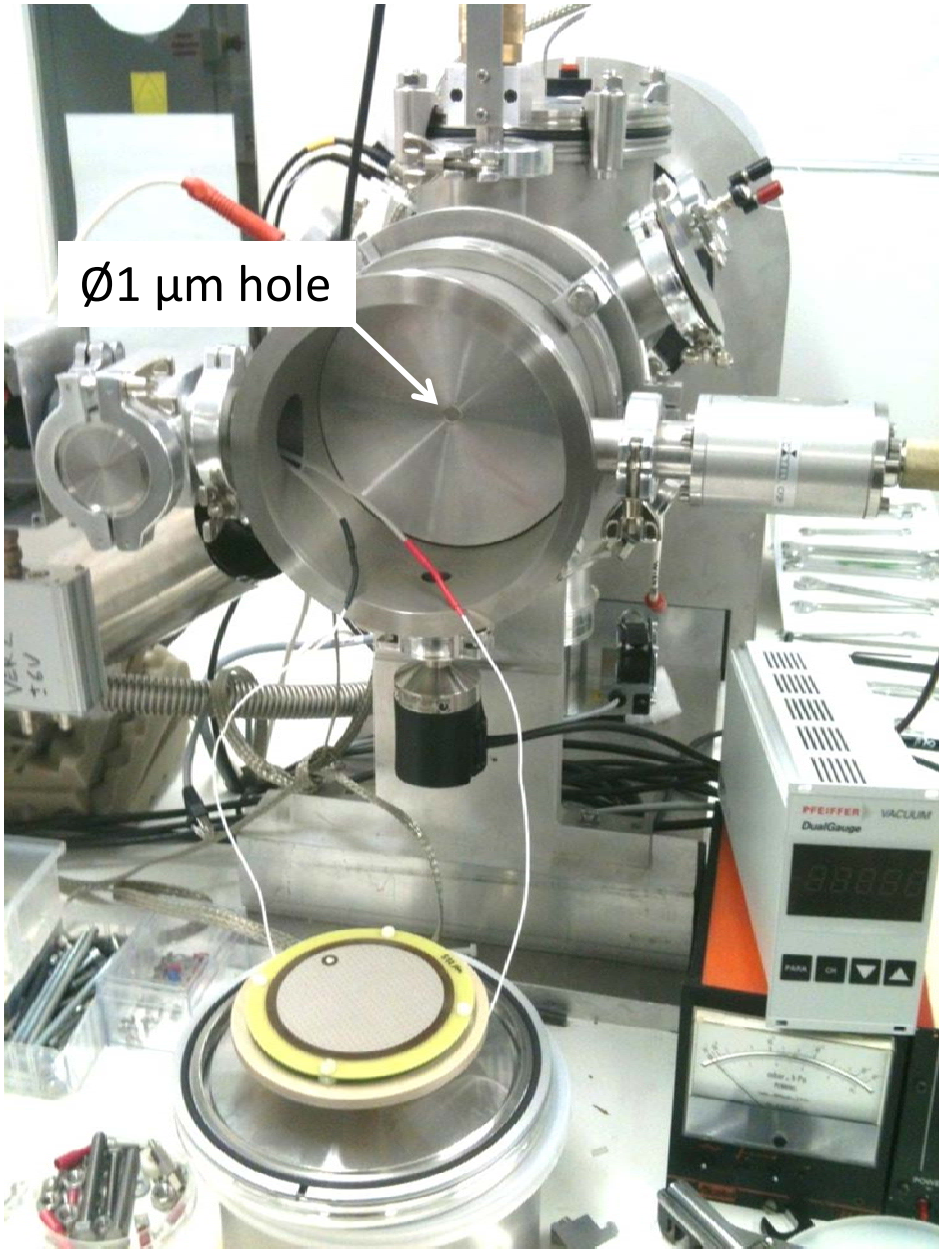
Aim:

- Allow a pressure ratio btw the source (10^{-5} mbar) and the ionization chamber (0-1500 mbar)
- Leave ion or electron beams enter into the ionization chamber

- 13 µm thick stainless steel disk
- Ø1 µm hole
- Glued with silver conductive epoxy (for vacuum tightness & grounding)



COMIMAC@LPSC



Setup:

- Chamber volume : 2 liters
- 128, 256 or 512 µm micromegas

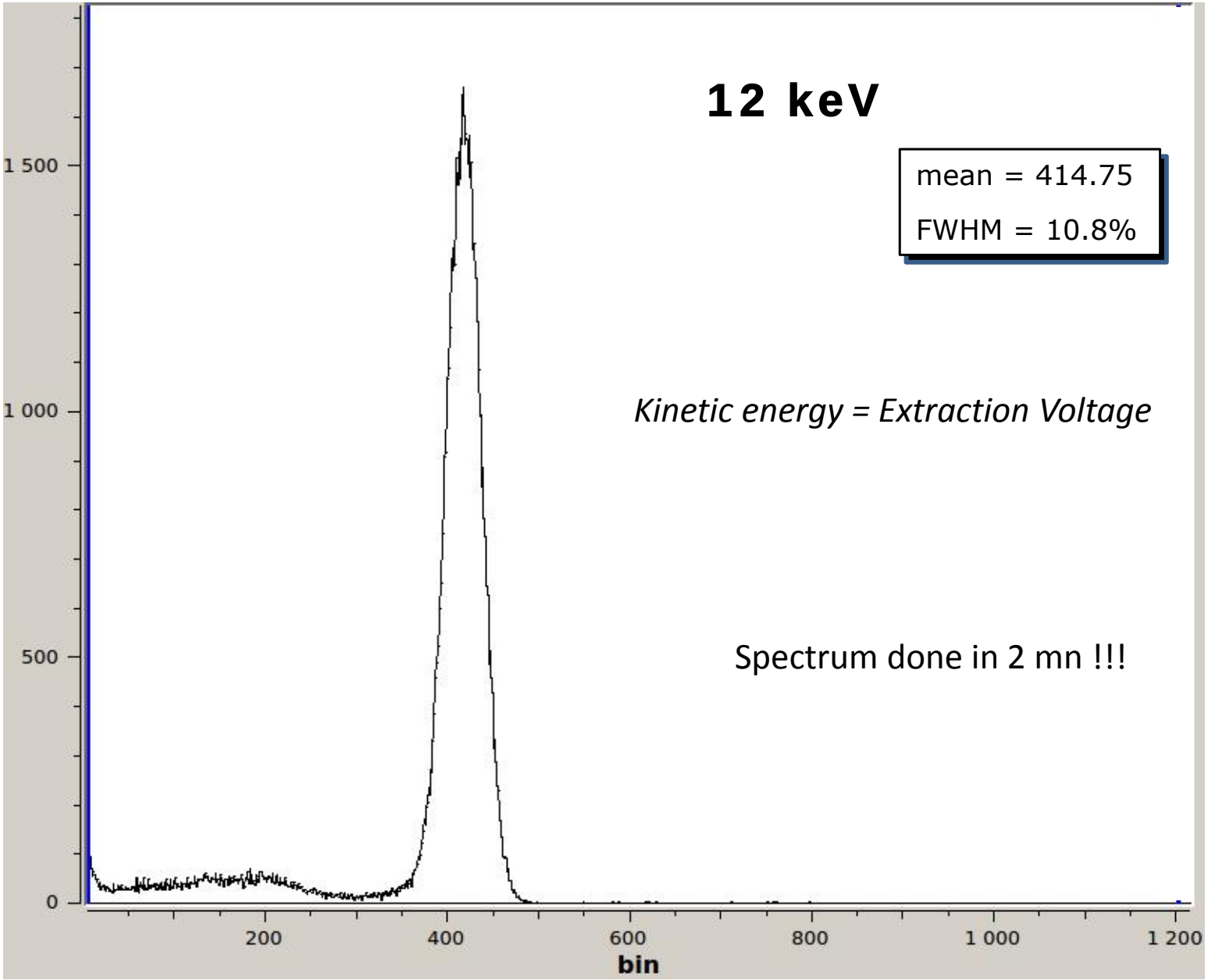
  (Ø 60 mm, bulked @ CERN)

Electrons Performance

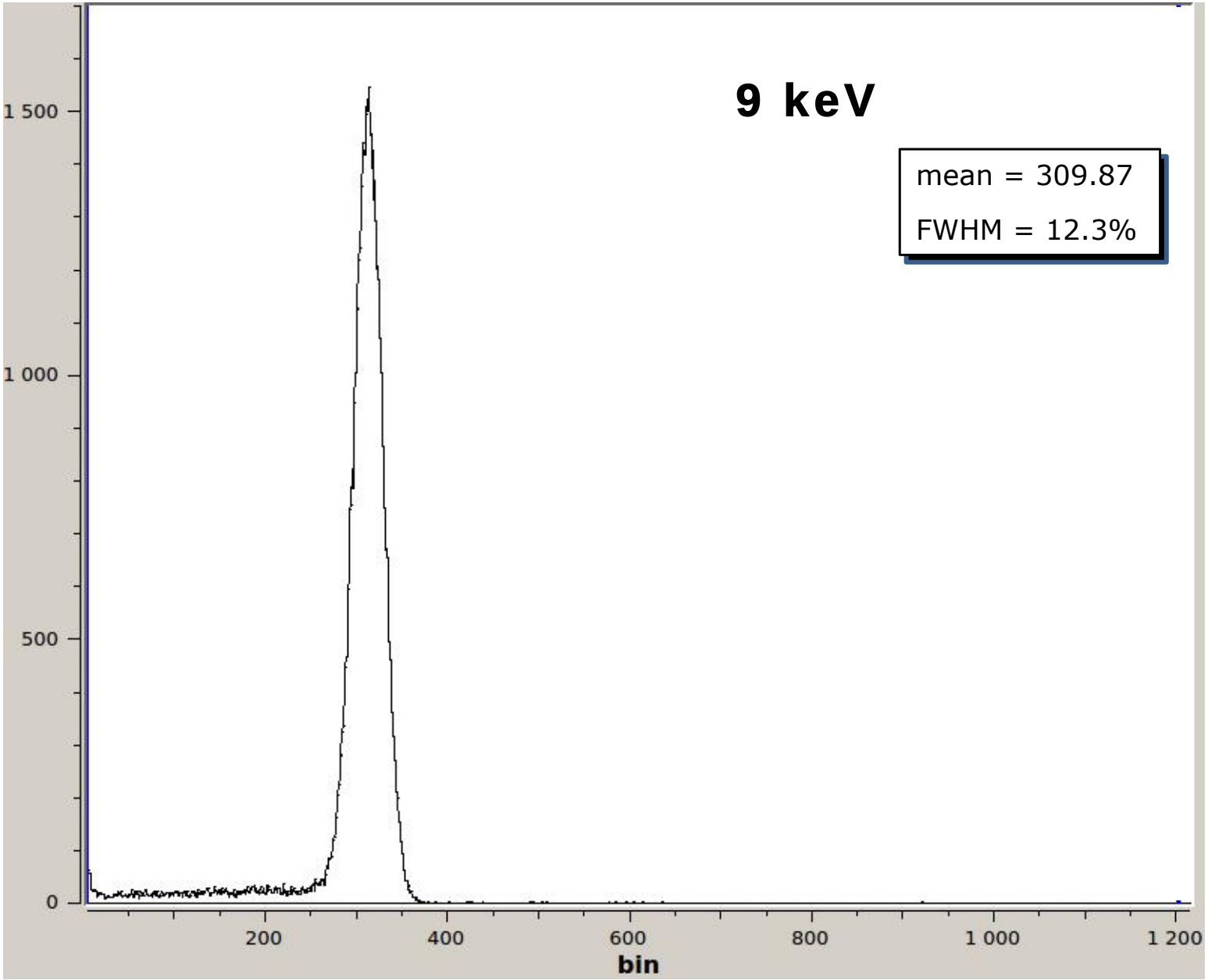
Set up :

- Electrons extracted from Nitrogen plasma in the source *(I=20 nA)*
- 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

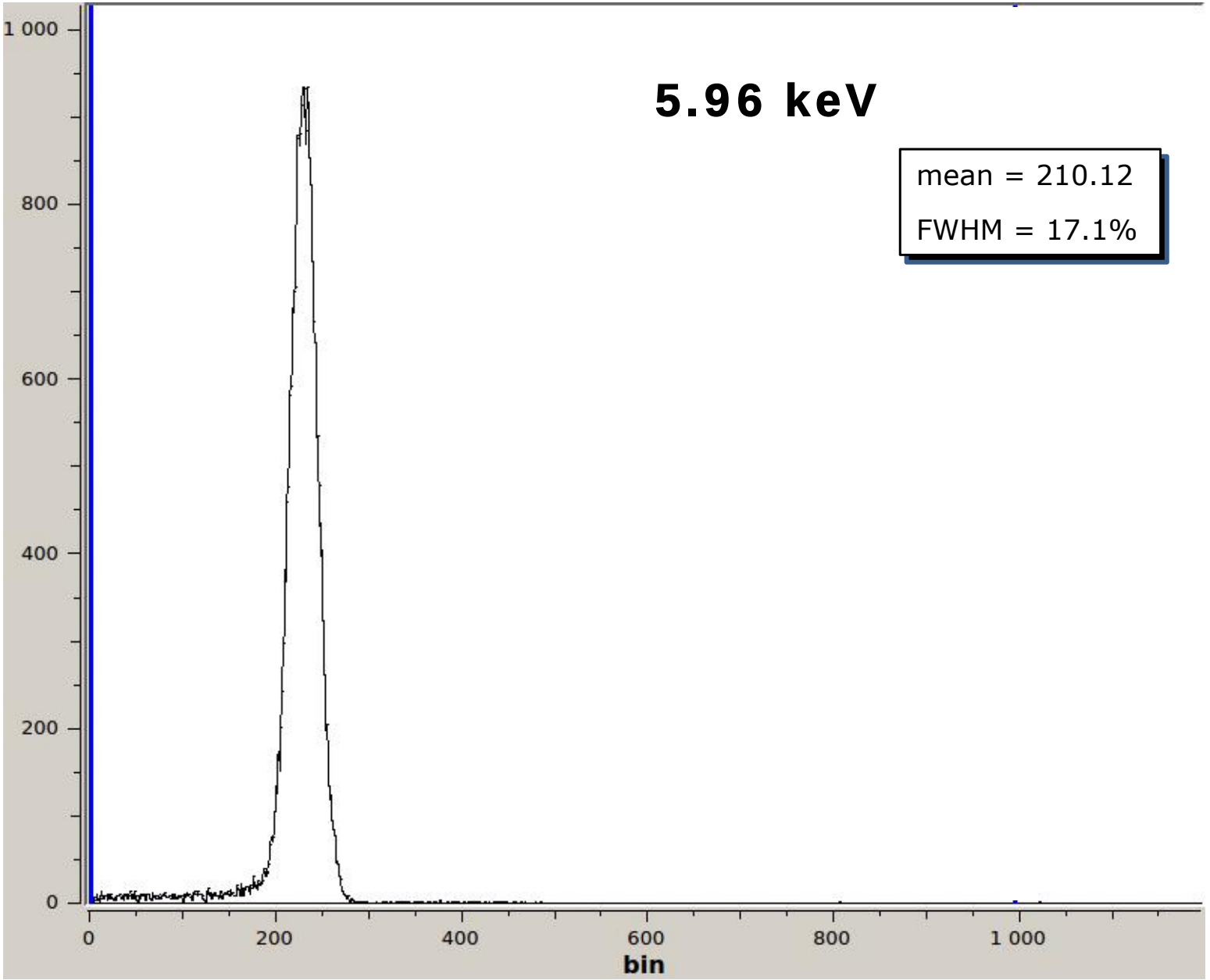
Electrons Performance



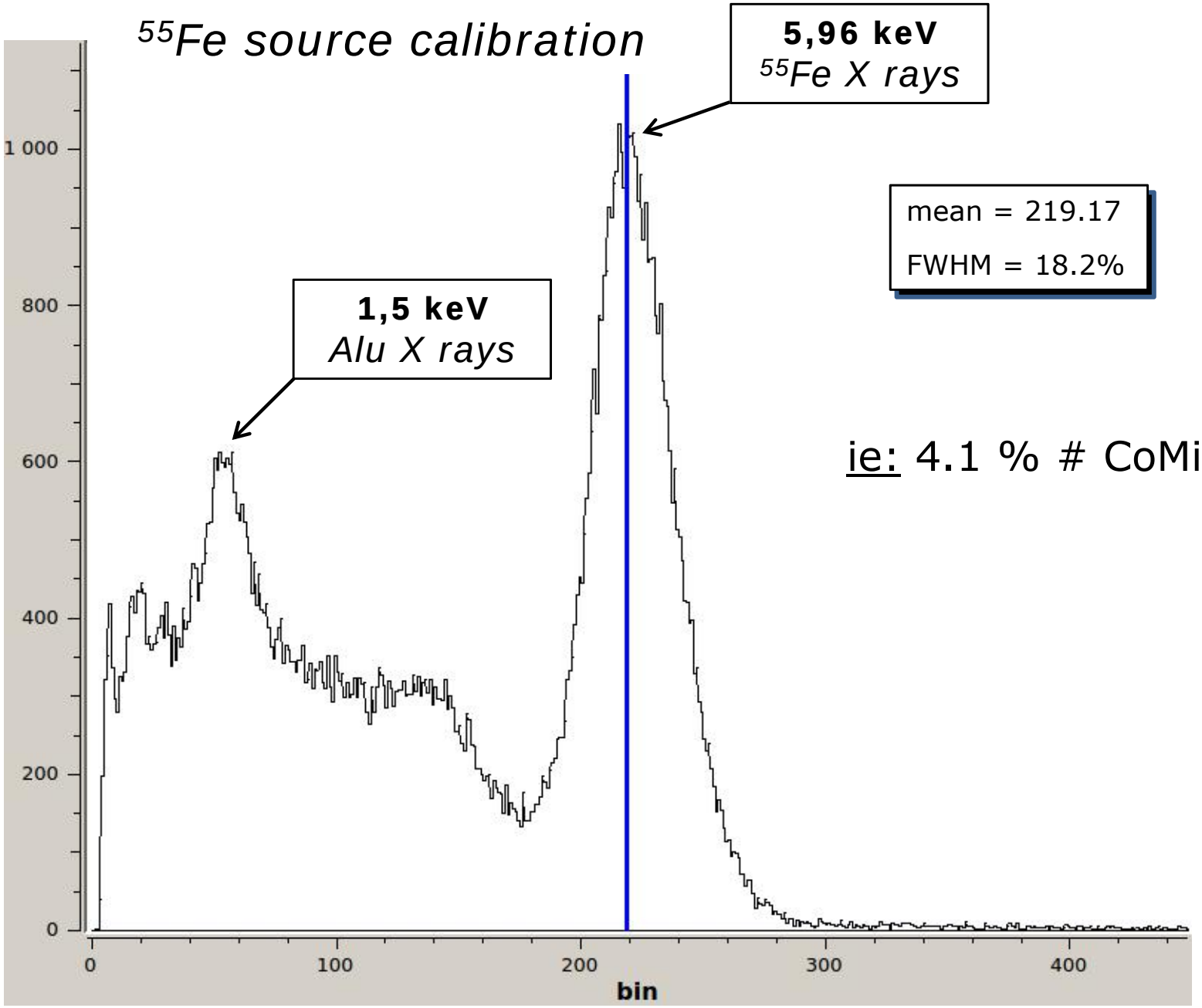
Electrons Performance



Electrons Performance

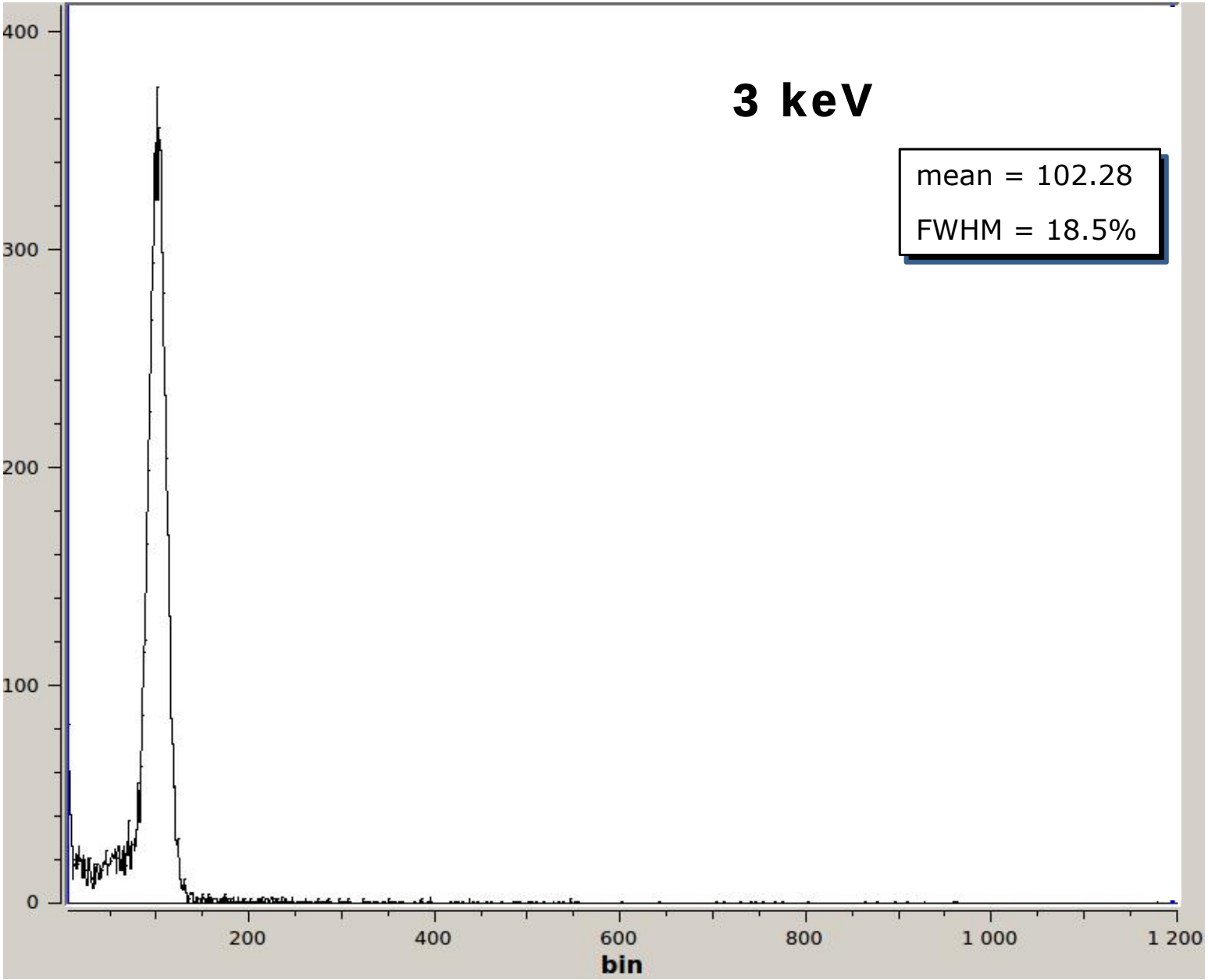


Electrons Performance

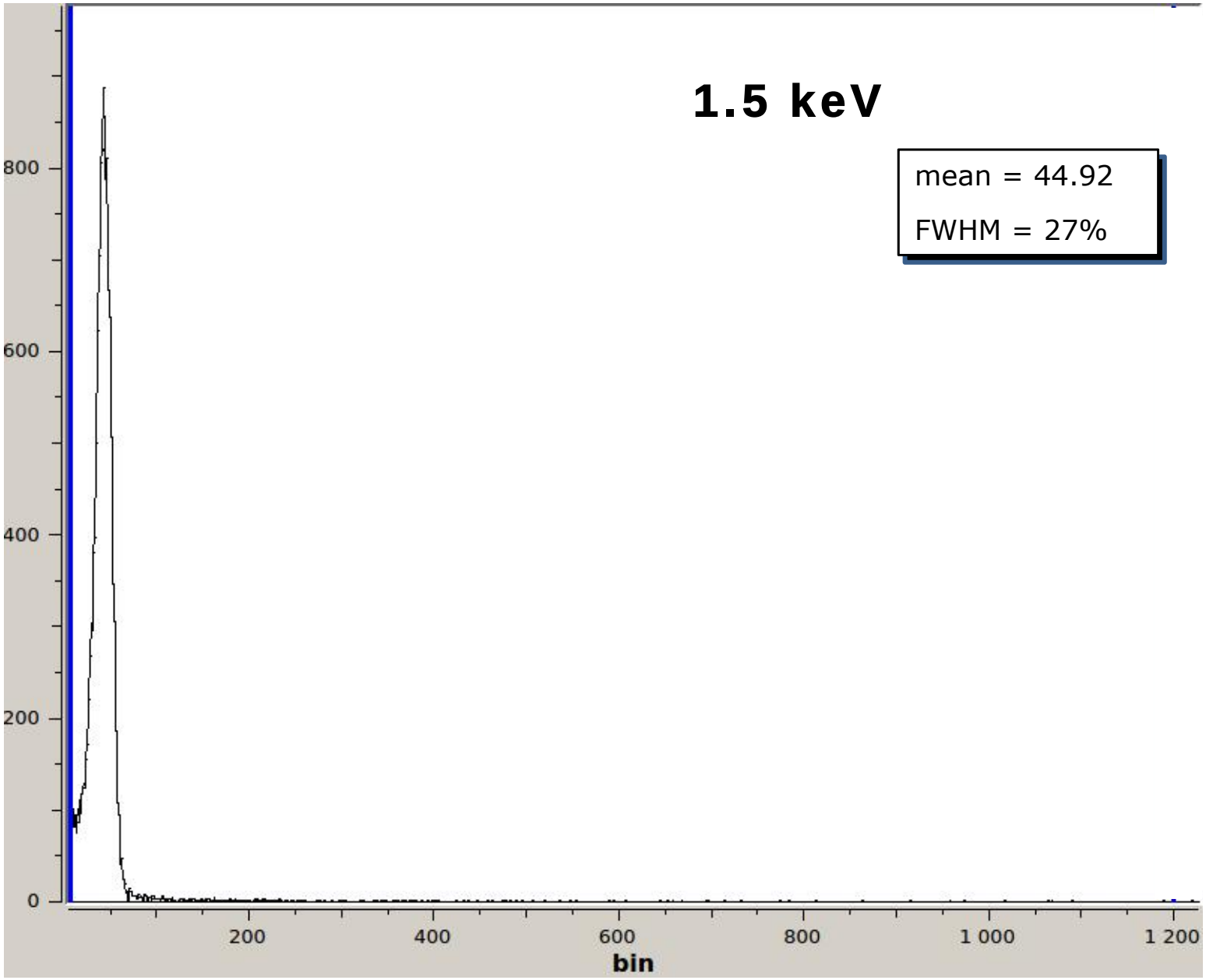


ie: 4.1 % # CoMimac

Electrons Performance

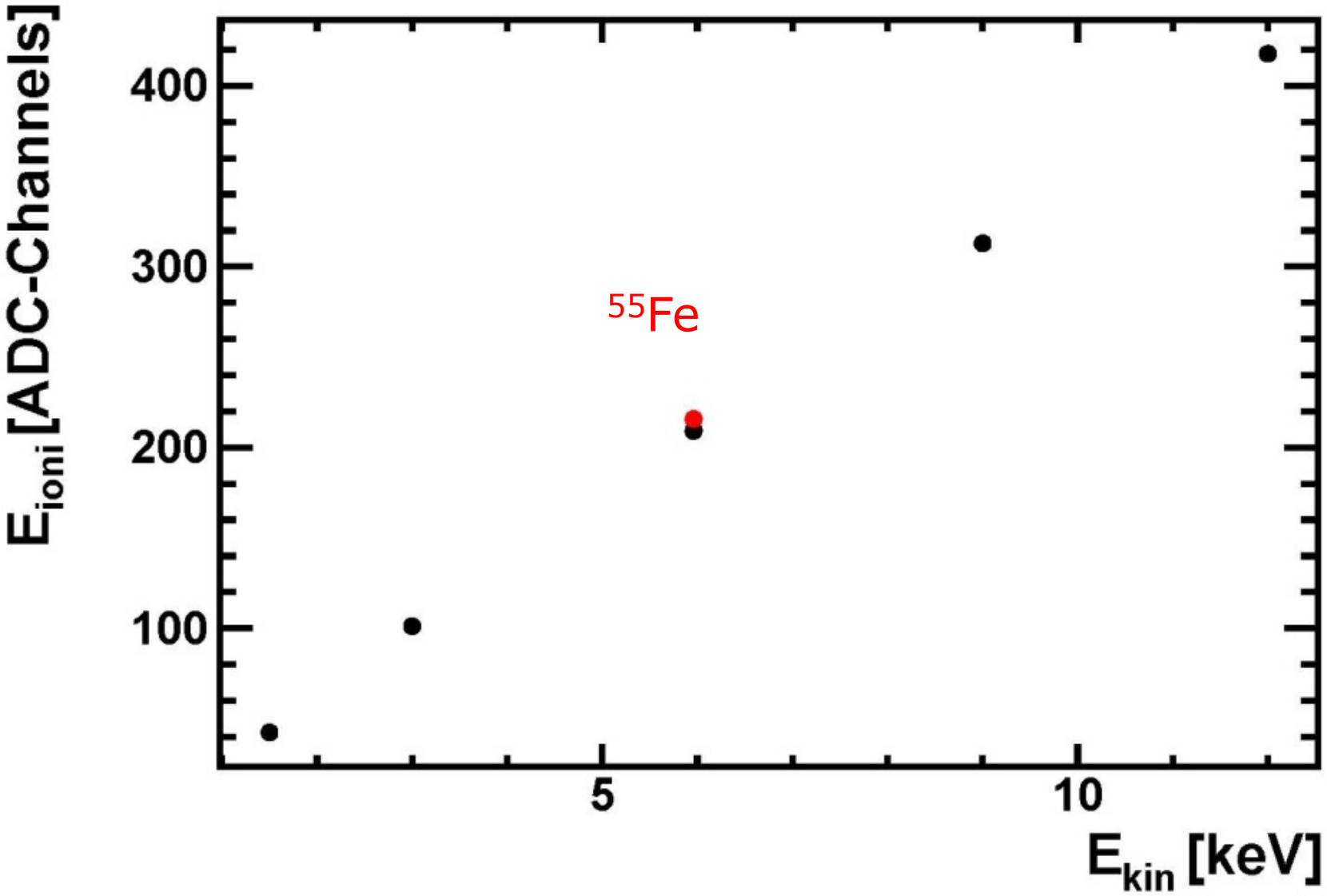


Electrons Performance

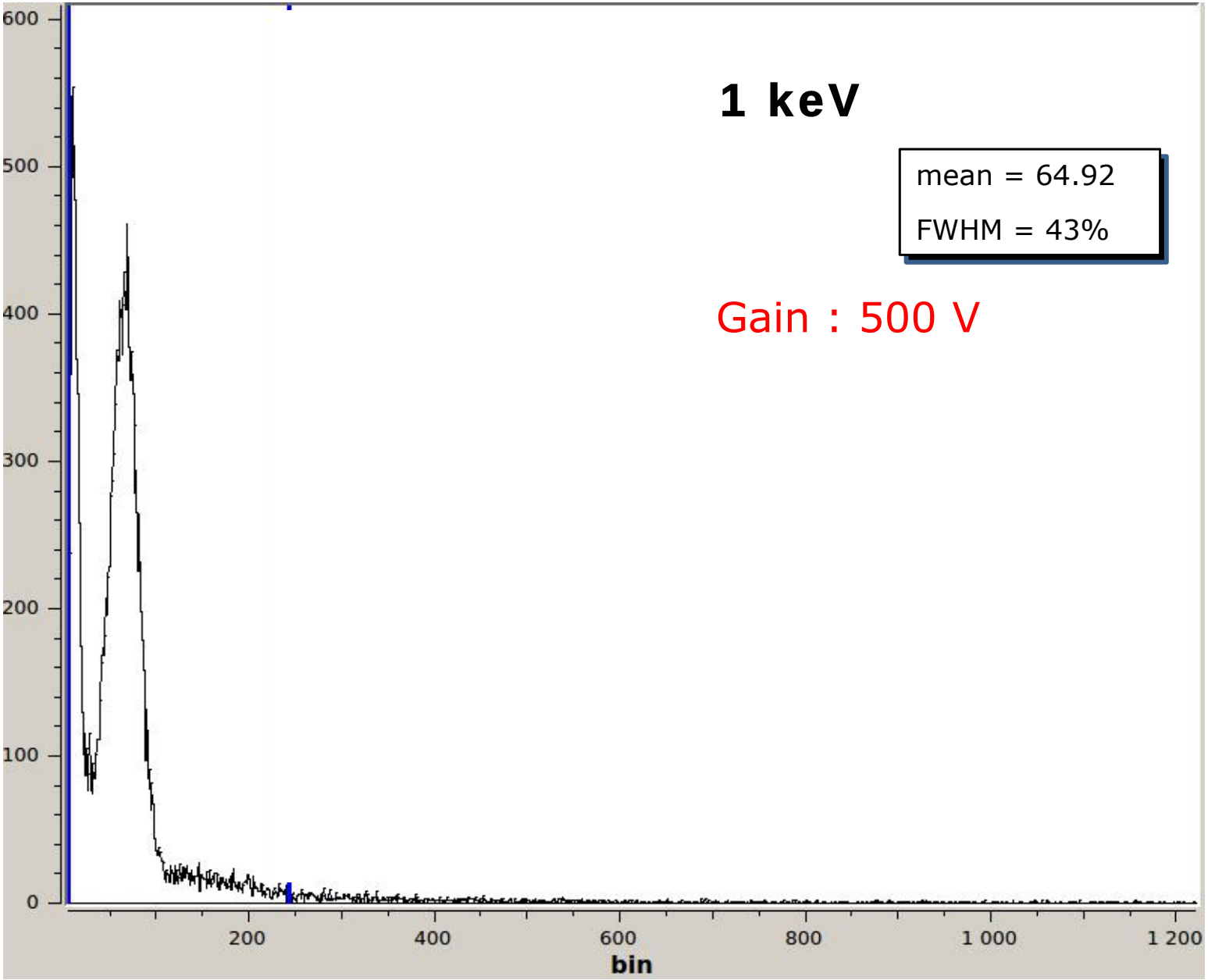


Electrons Performance

Electron Linearity response



Electrons Performance

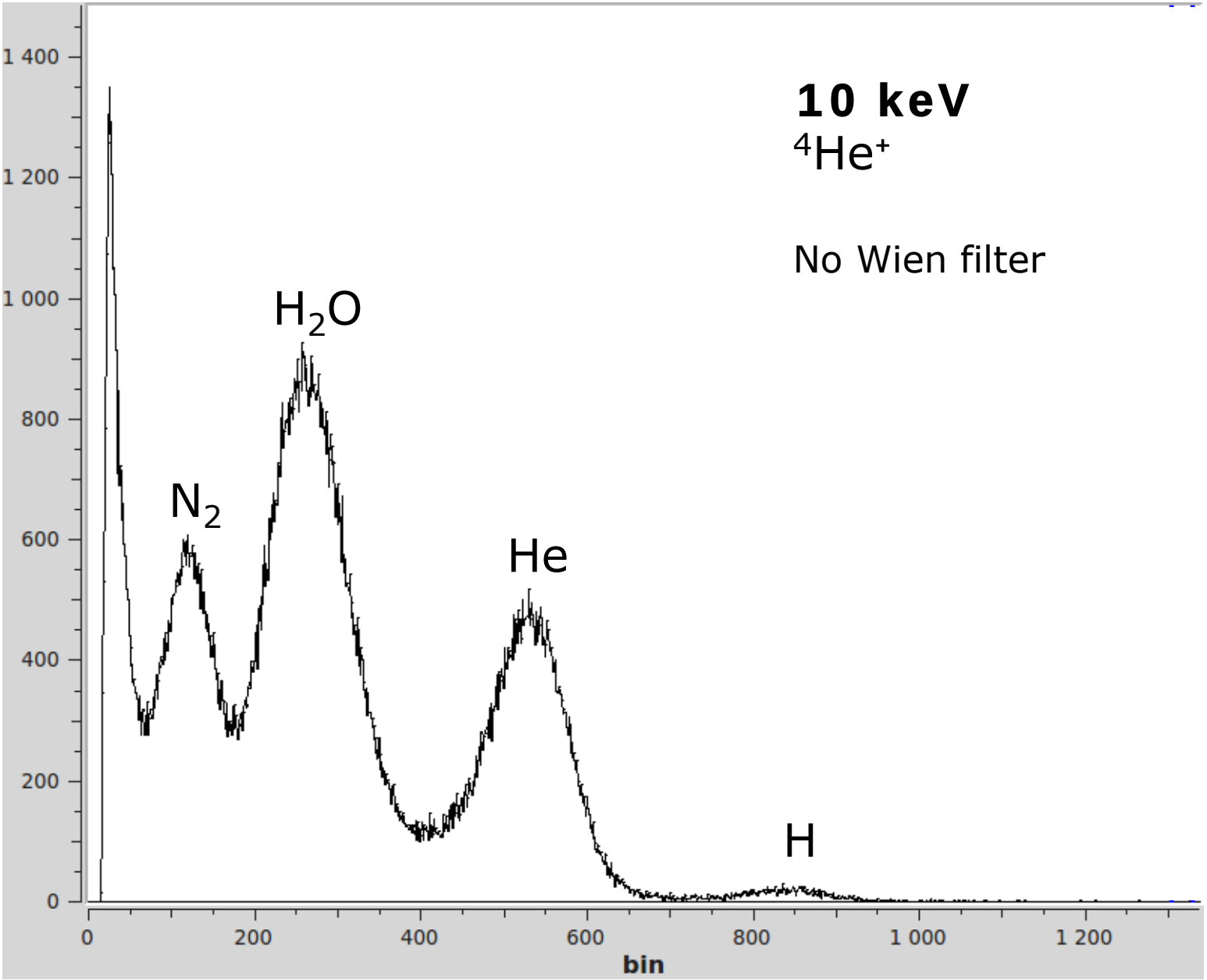


Ions Performance

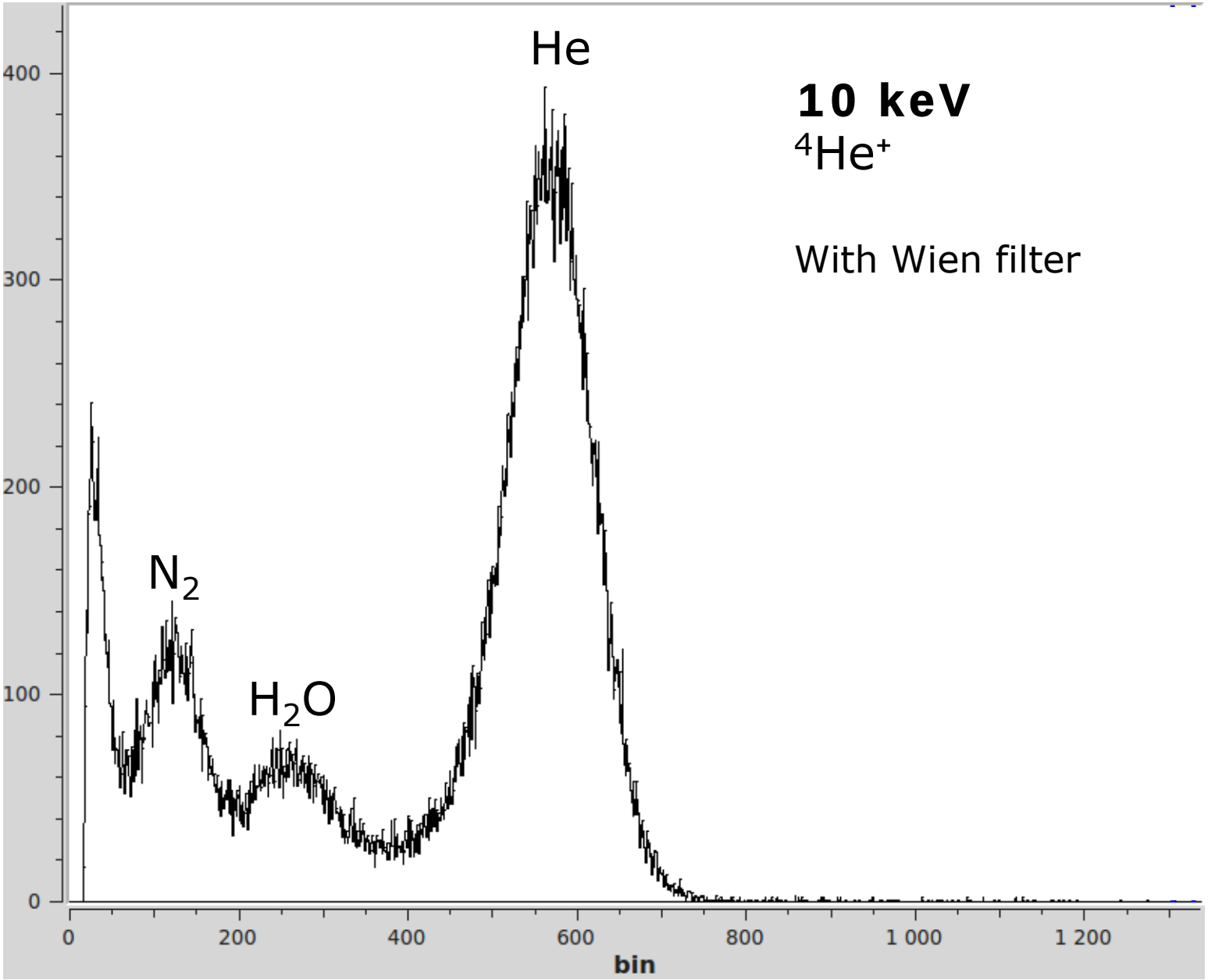
Set up :

- Ions : $^4He^+$
- 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

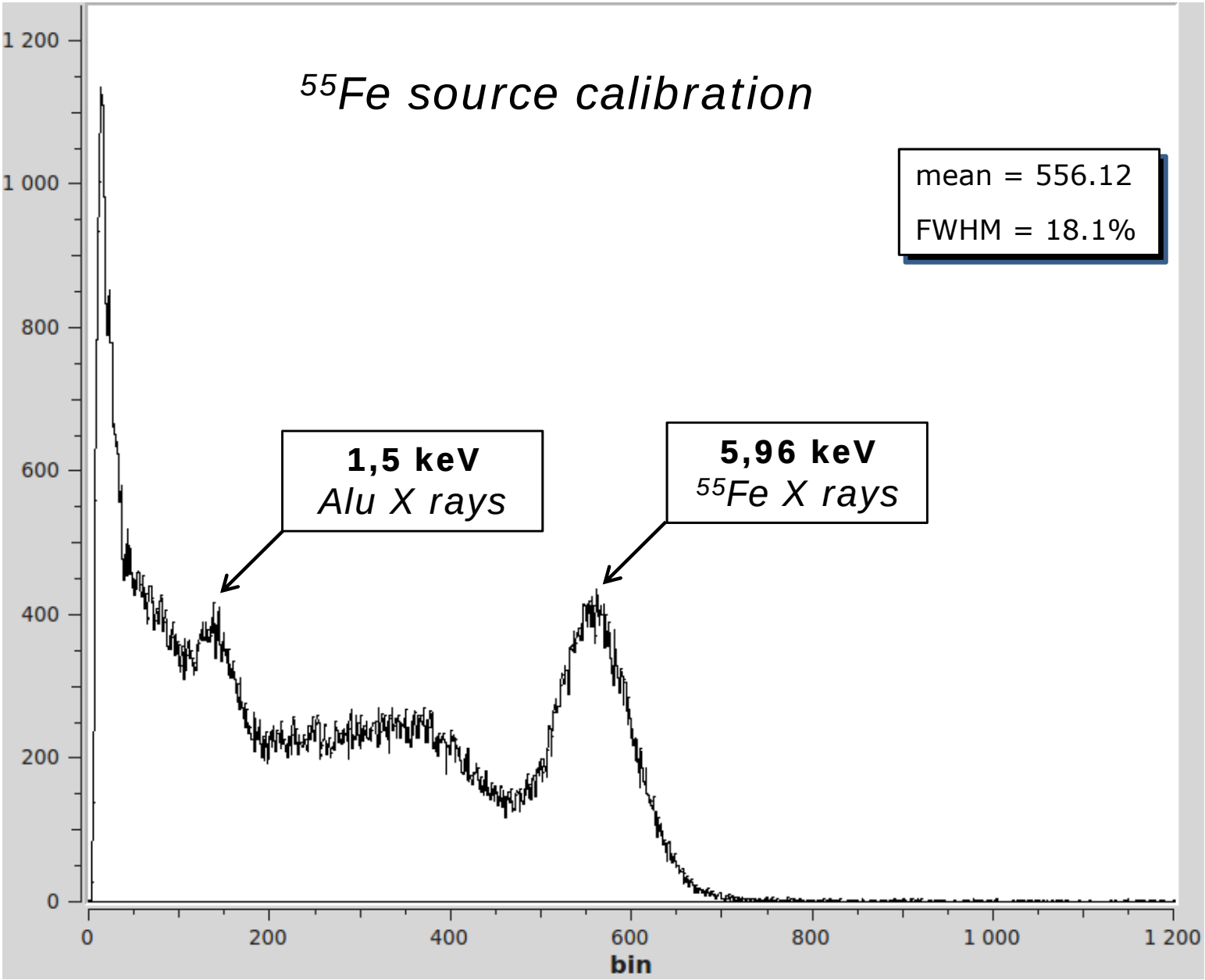
Wien Filter


10 keV
$^4He^+$
No Wien filter
H_2O
N_2
He
H
1 400
1 200
1 000
800
600
400
200
0
0
200
400
600
800
1 000
1 200
bin

Wien Filter


He
10 keV
$^4He^+$
With Wien filter
N_2
H_2O
400
300
200
100
0
0
200
400
600
800
1 000
1 200
bin

Ions Performance



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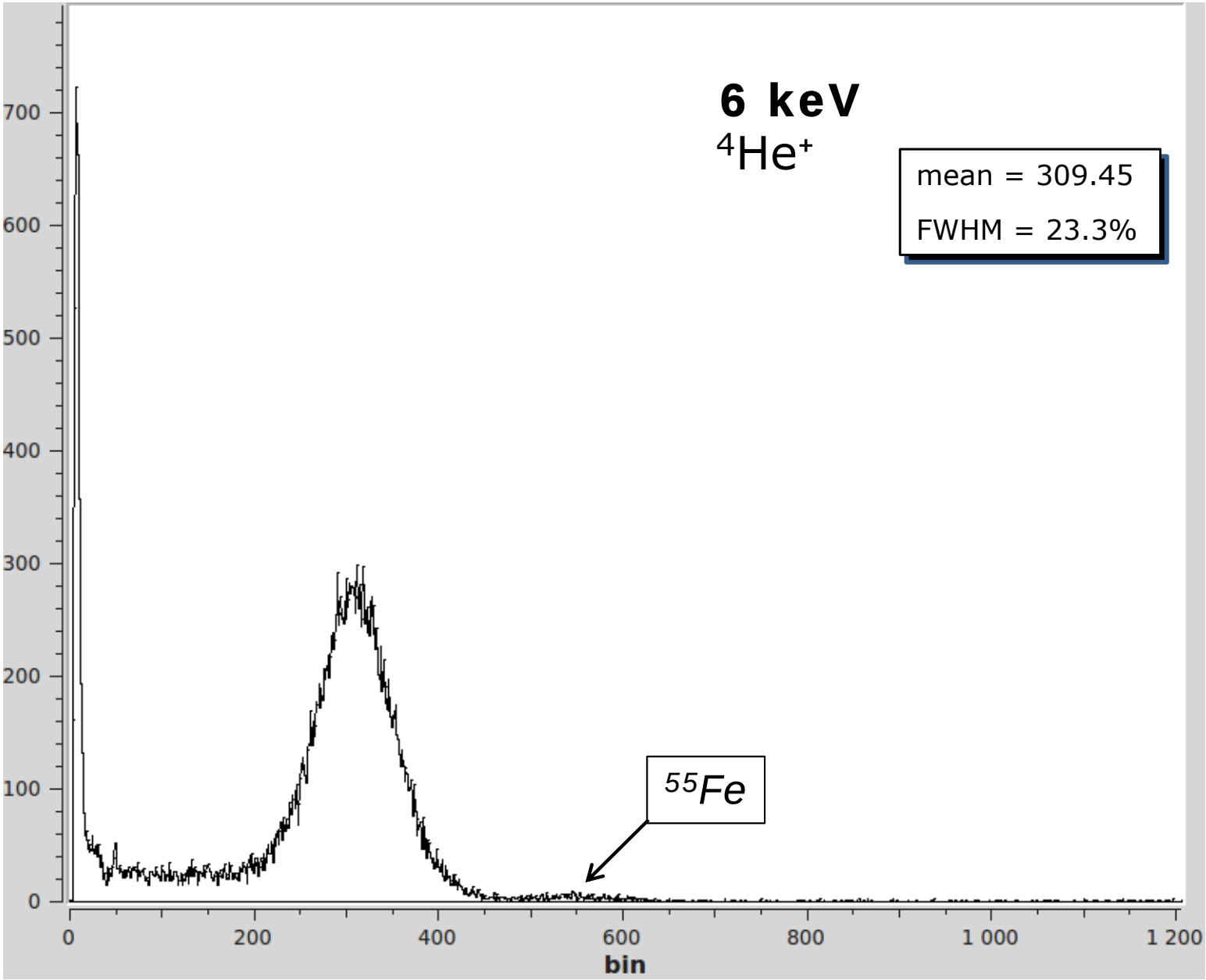

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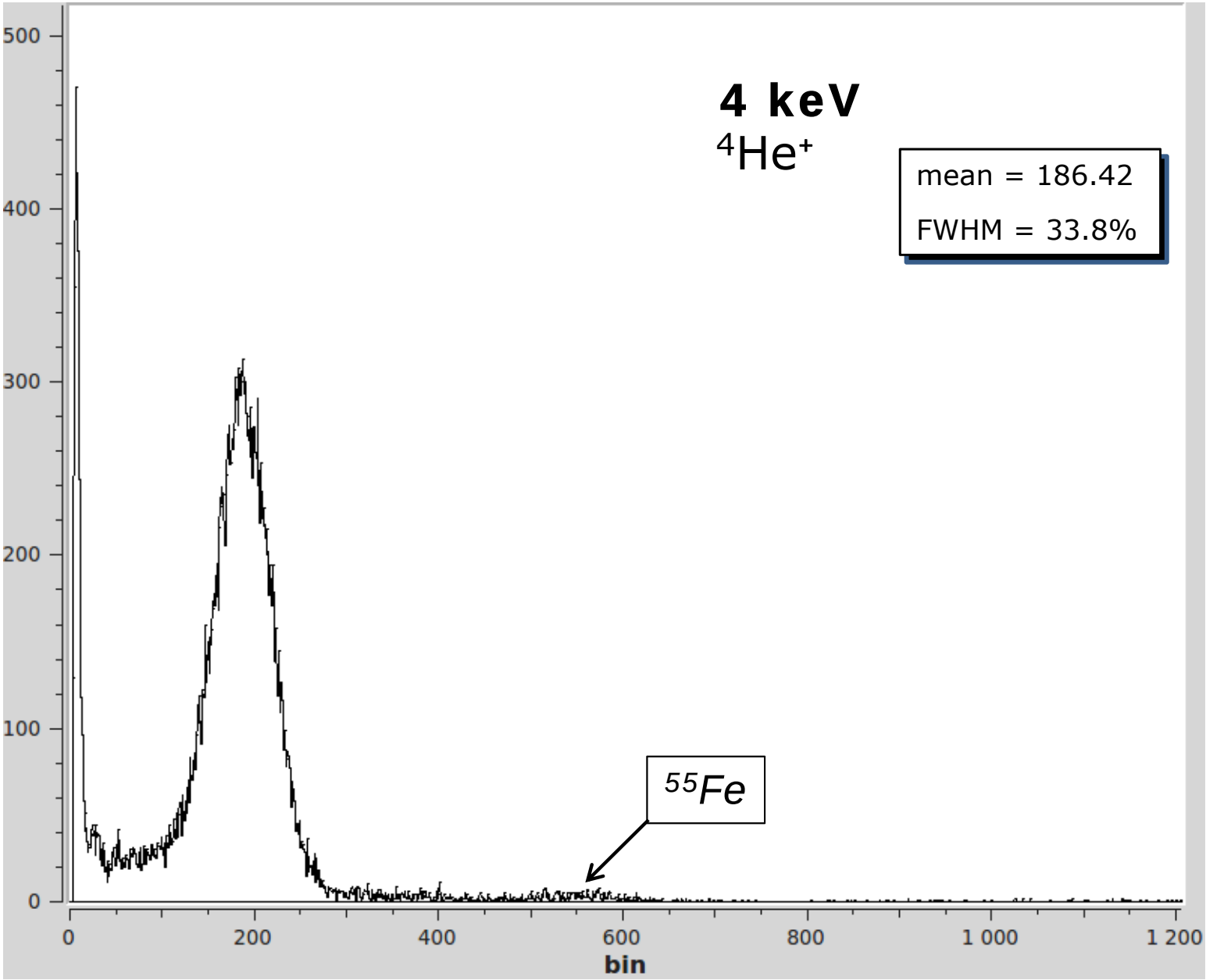

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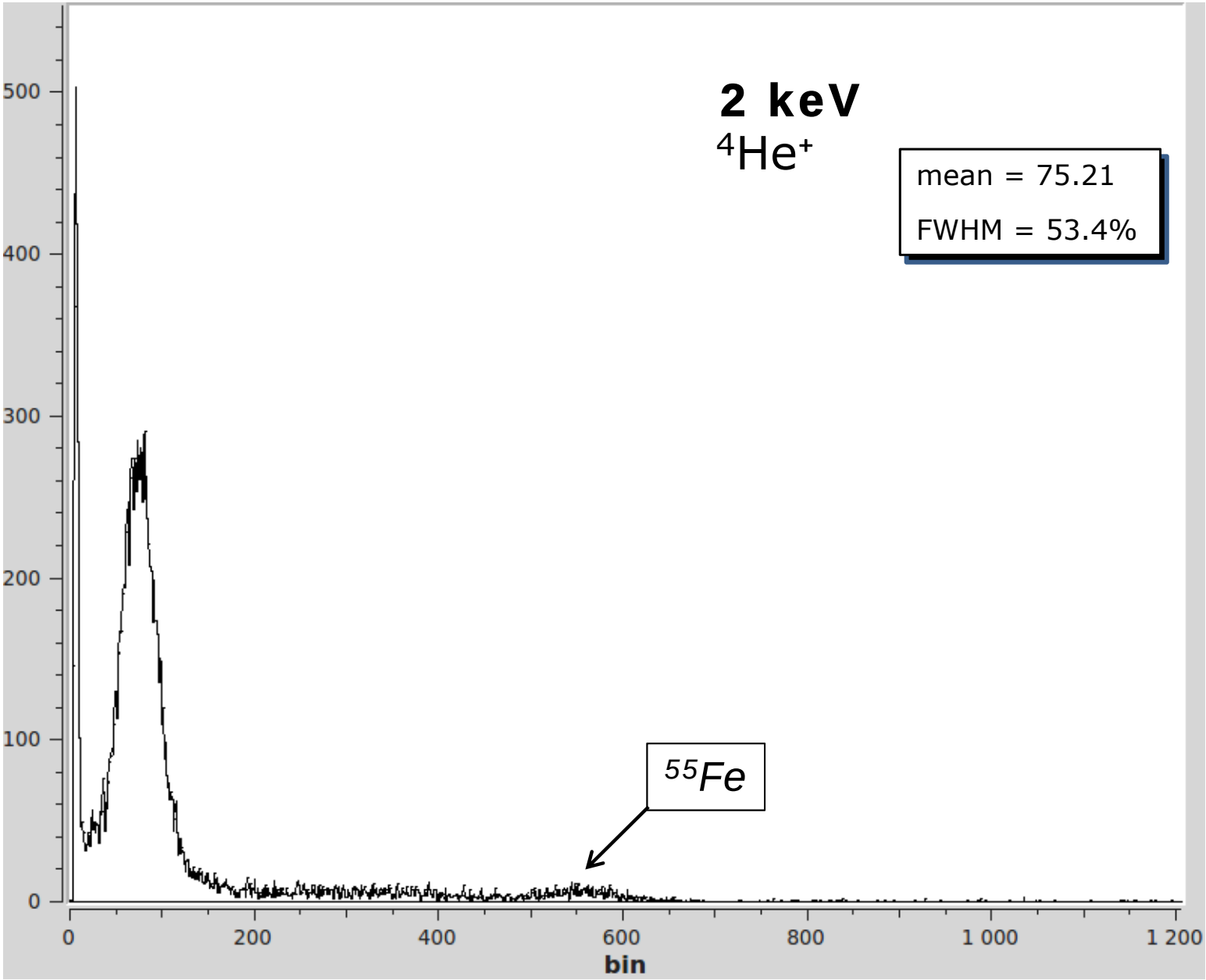

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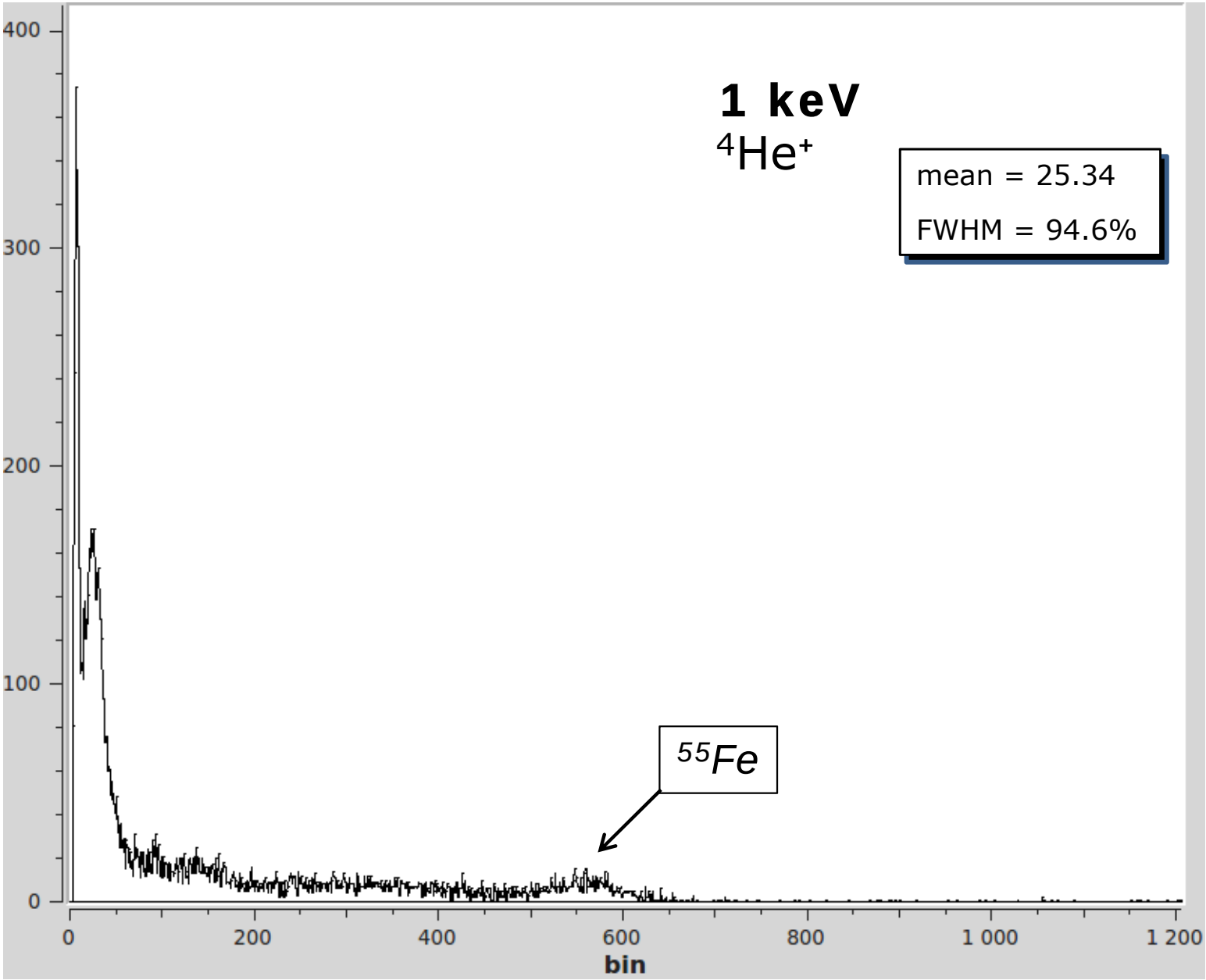
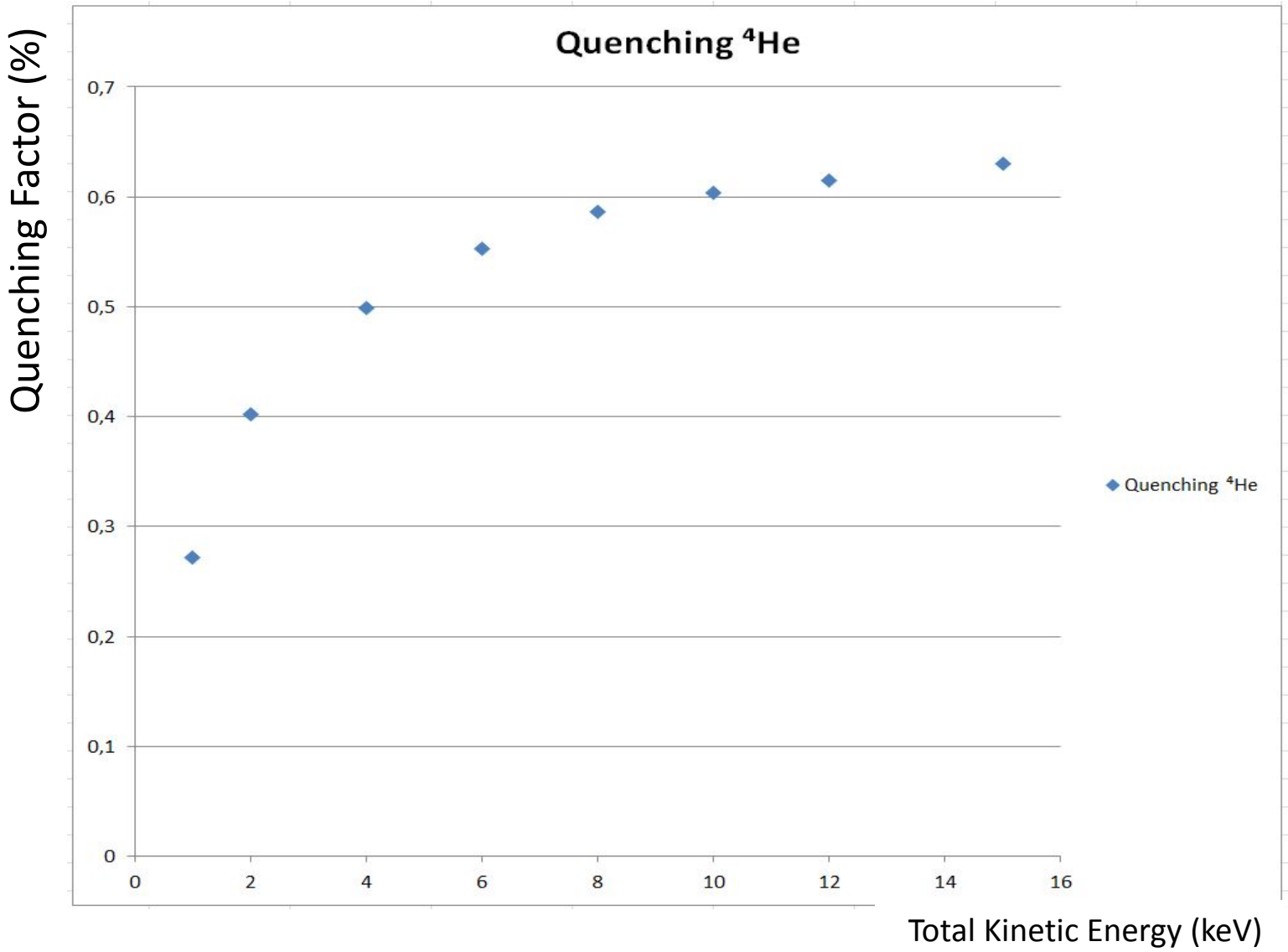
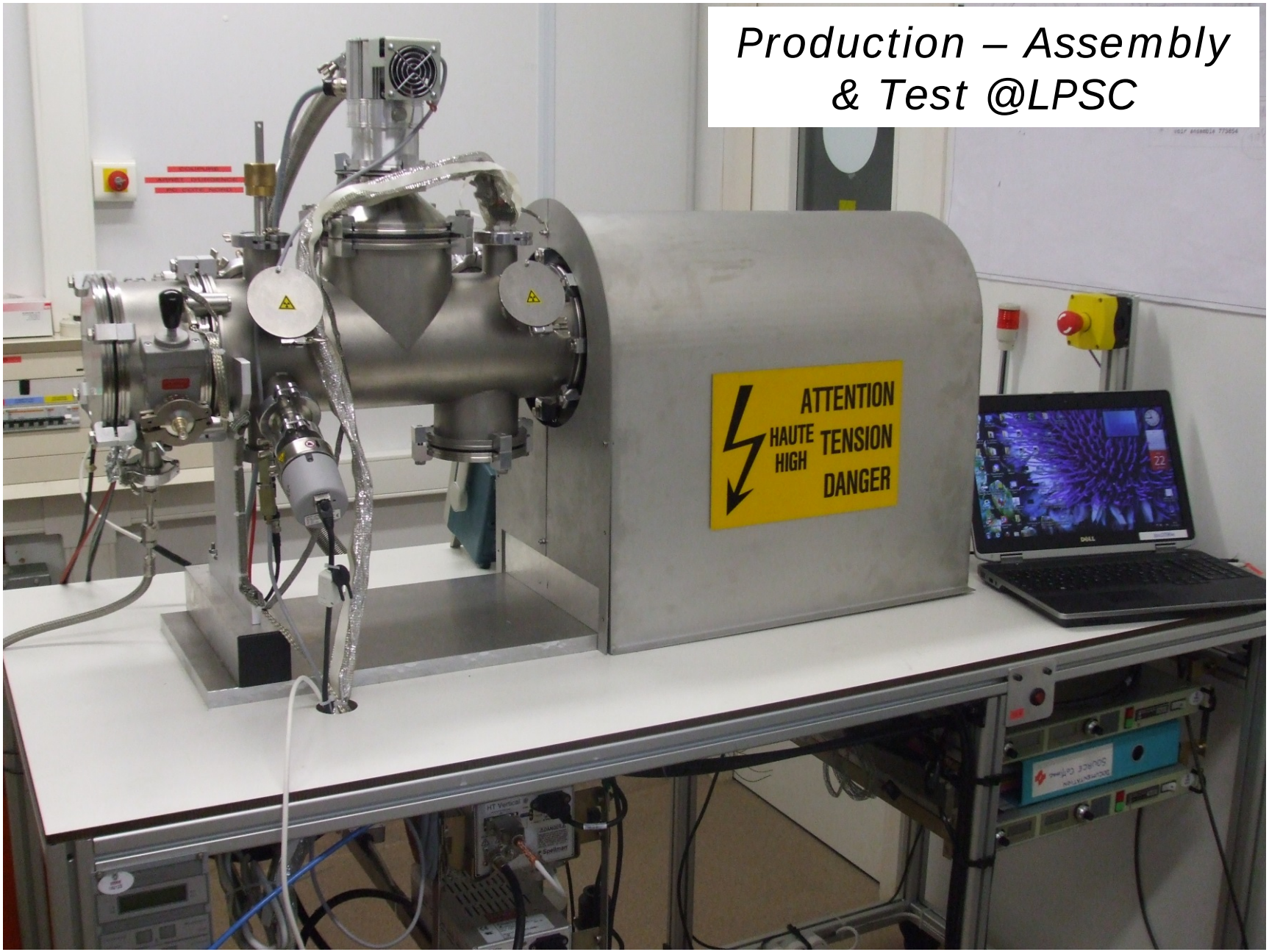


Ions Performance



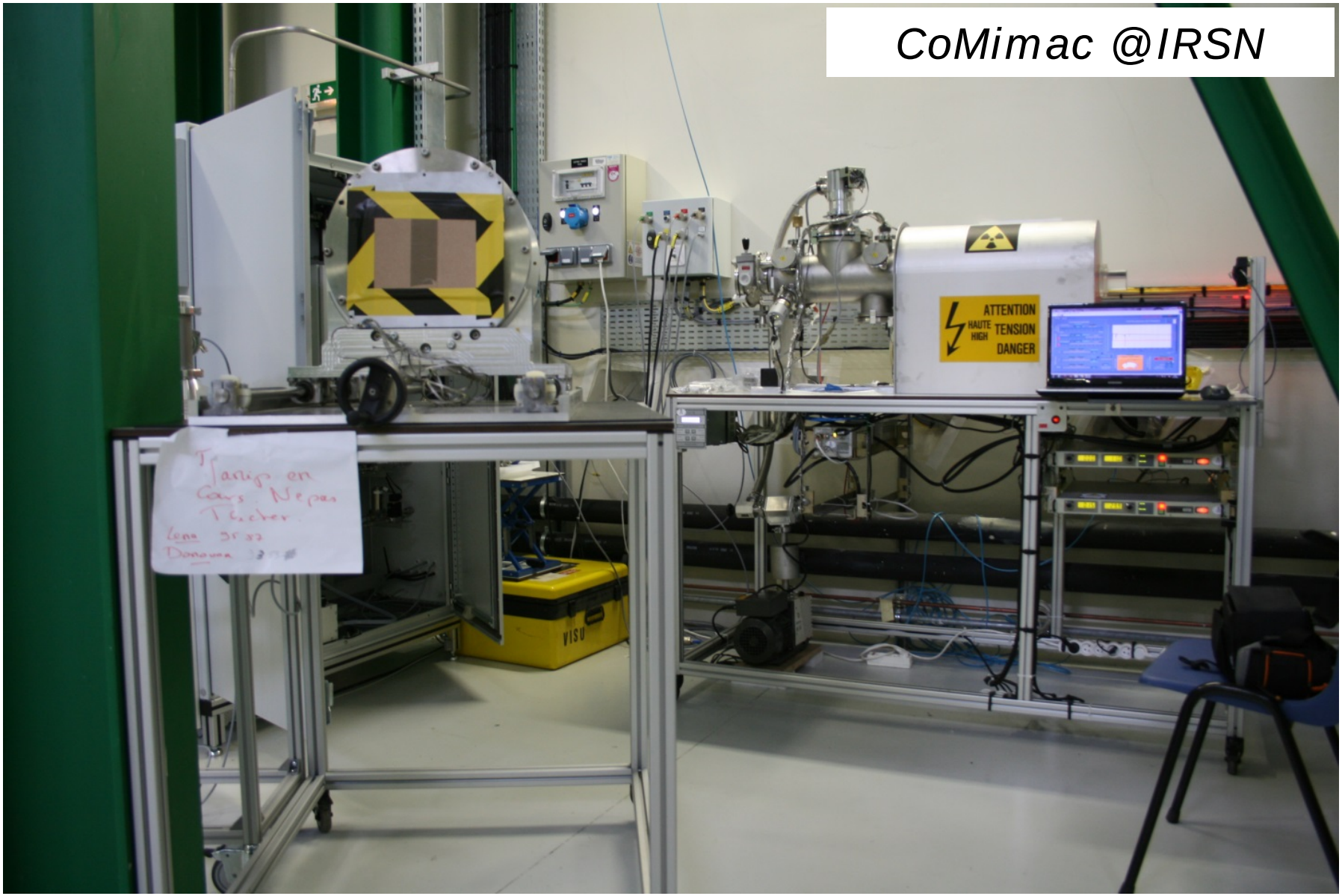
arXiv:0810.1137 **:** *Santos.D et al : Ionization Quenching Factor Measurement of Helium 4*

Production – Assembly & Test @LPSC

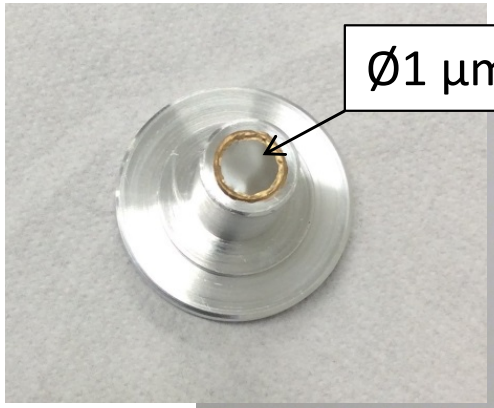



Shipping

COMIMAC@IRSN-LMDN



Saclay Sphere@Grenoble



Conclusion

Summary :

- Ion or electron beams
- Kinetic energies up to 50 keV in electrons and 100 keV in ions (ion^{2+})
- Pressure range 0-1500 mbar
- Ions q/m selection
- Allows calibration at any energies (included in low pressure gases)
- Can be connected to any gaseous detector

Applications :

- Ionization Quenching Factor measurements
- Gaseous detector test facility *(high counting rates (1 kHz/µm²))*
- Gas quality monitoring
- …

Backup

Ionizing Radiation

RADIOPROTECTION

ETUDE DE POSTE

Expérience : COMIMAC

Date de la mesure: le 16 avril 2013.

Localisation: Hall B, Salle 6, Moucherotte – Mont Aiguille.

Expérience: COMIMAC. Version du prototype : **COMIMAC 1- 50 keV**

Responsable: Daniel SANTOS.

Opérateur: mesures effectuées avec D.SANTOS et J.F. MURAZ

Appareil de mesure utilisé: TARGET Fieldspec.

Agent ayant effectué la mesure: William REGAIRAZ, PCR.

Qualification du faisceau: Protons

Réglages:

1/Tension d'accélération 40 kV, courant faisceau : 12 nA.
2/ Tension d'accélération 50 kV, courant faisceau : 30 nA

Résultats des mesures: (Voir Annexe1)

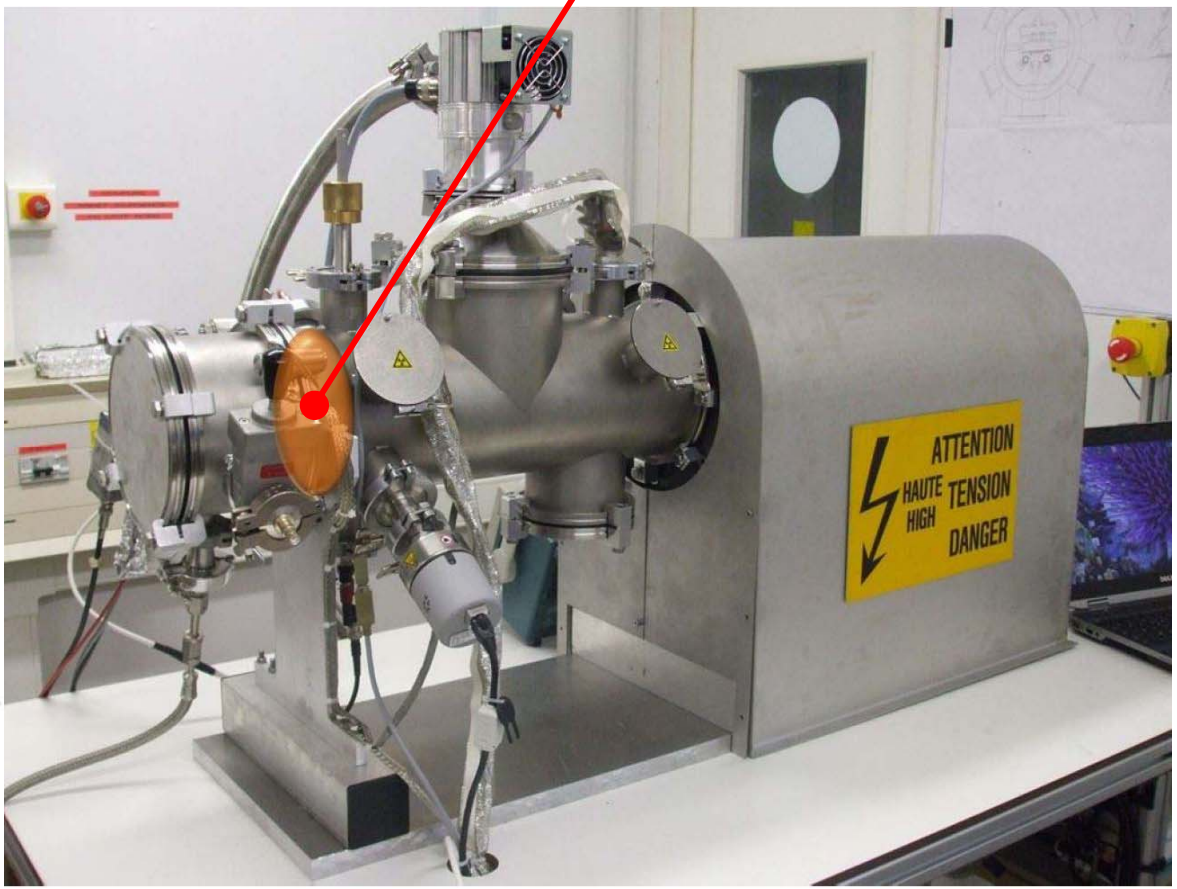
Bruit de fond : 100 nSv/h

Dans les 2 cas :
Bruit de fond au contact de tout point hors **cage de Faraday**

Contre la Cage de Faraday (rep 1 annexe 1): 0.3 µSv/h

W. REGAIRAZ
Service Sécurité Radioprotection

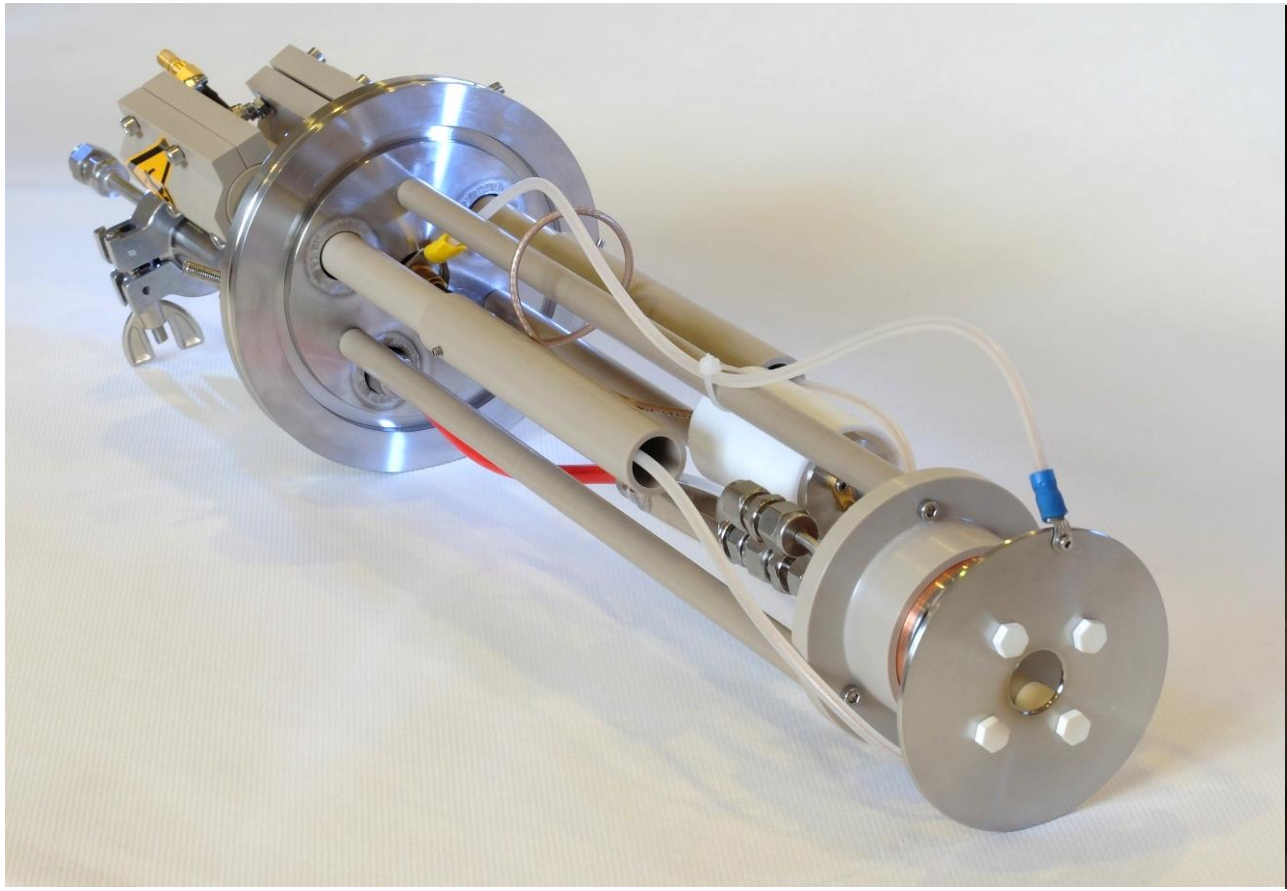
Protons : 50 keV , 30 nA
0,3 µSv/h max

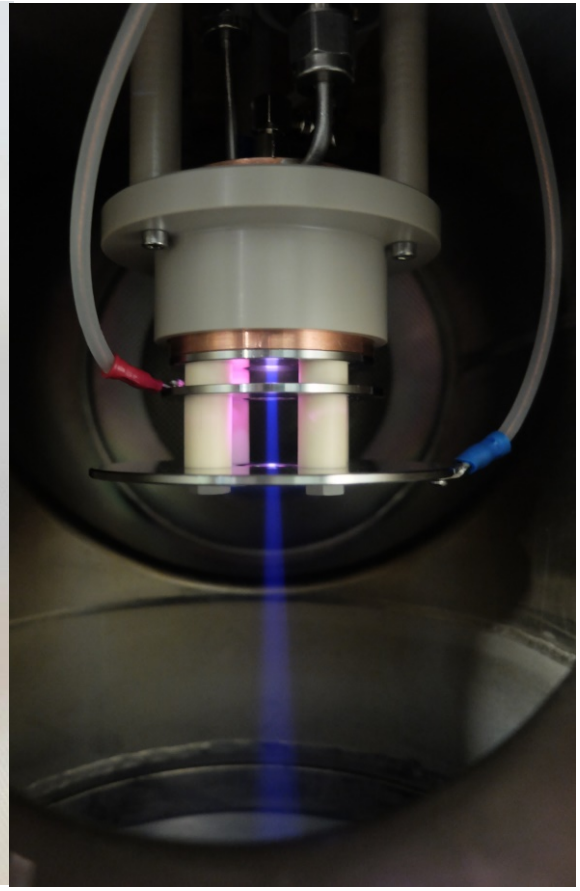


IE-Gun product

"Plug and Play"
Electron or Ion source 0-20 kV

High quality ion and electrons beams for surface physics
High power welding electron beam
Ion beam cleaning
Ion beam deposition
Ion and electron beam for accelerator
Ion beam figuring





POLYGON PHYSICS