A table-top ions - electrons facility for gaseous detectors calibration and Ionization Quenching Factor measurement

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Introduction

Directional detection is a dark matter search strategy based on the measurement of the WIMP flux anisotropy due to the solar system motion with respect to the dark matter halo. The MIMAC experiment is a µ-TPC matrix project for directional dark matter search. The main purpose of this project is the measurement of the energy and the direction of few keV nuclear recoils produced by elastic scattering of WIMPs. For such nuclear recoils, there is a difference between the kinetic energy and the ionisation energy. This difference is parametrized by the **Ionization Quenching Factor**, it is defined as the ratio of measured ionization energy and the initial kinetic energy of the nuclear recoil. IQF measurement is a key point for a precise measurement of the recoil nuclei kinetic energy.

In order to measure the Ionization Quenching Factor in low pressure gases, LPSC has developed a **highly miniaturized table top source facility** called CoMimac which is able **to produce calibrated ions**, selected in q/m by a Wien filter, with a kinetic energy range **up to 50 keV**.

However, for low pressure gases, calibration using X-rays sources is inefficient due to the gas transparency. CoMimac was also designed **to produce calibrated electrons** at such energies allowing an efficient detector calibration.

Highly miniaturized table-top source

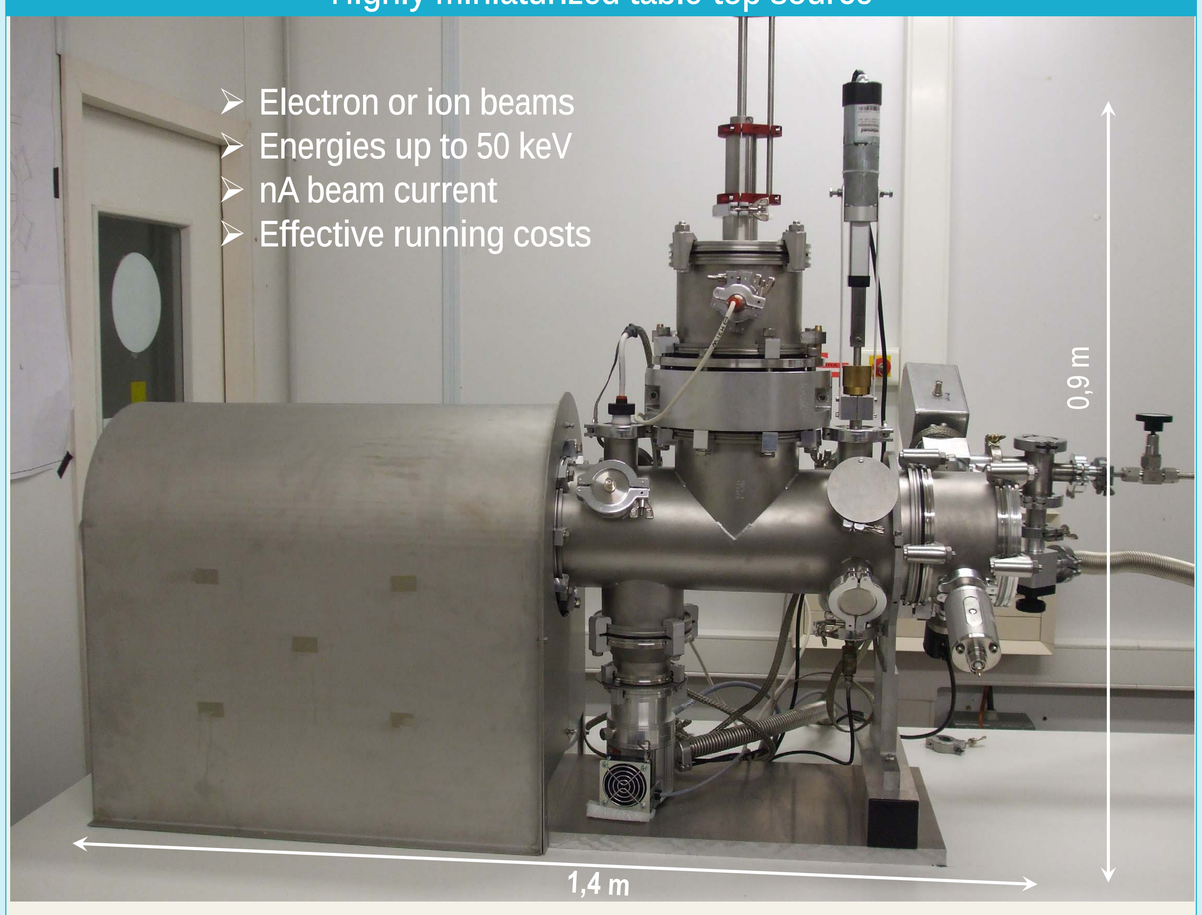
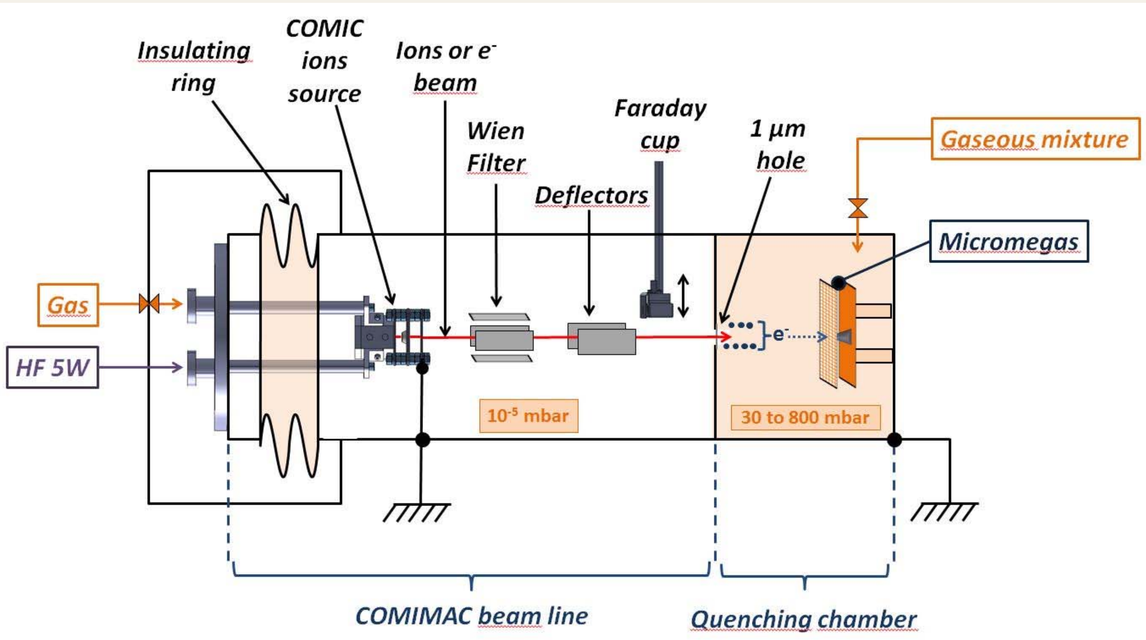


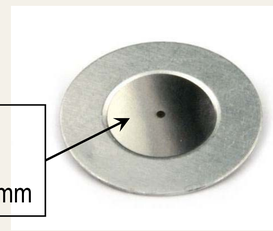
Table-top source setup

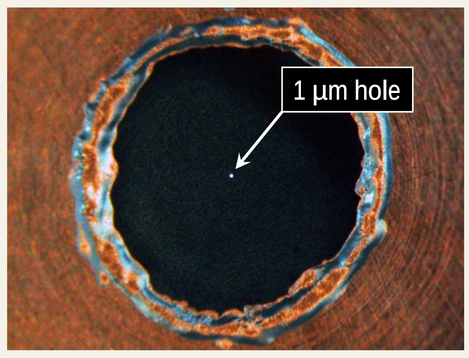


1 µm hole chamber interface

The interface in-between the gas chamber and the source is made via a 1 µm diameter hole done by a laser in a 13 µm thick stainless-steel foil. This interface allows:

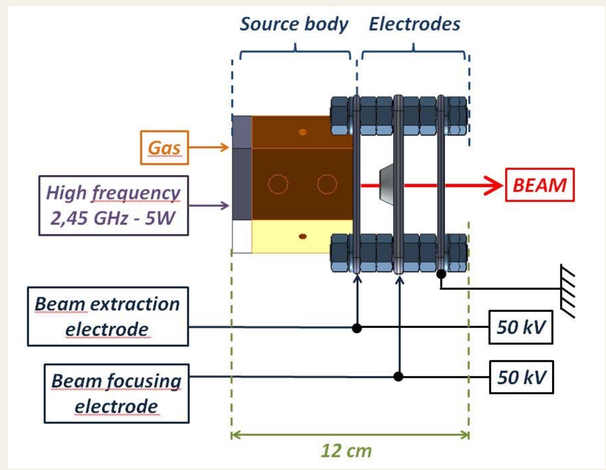
- Ions or electrons to enter into the gas chamber
- A pressure ratio between the source (10^{-7} mbar) and the chamber (0-1500 mbar)

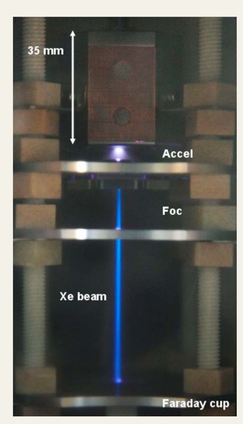




The COMIC source

The *"COmpact Microwave Coaxial"* source is an highly compacted Electron Cyclotron Resonance (ECR) source developed at LPSC. Pulsed at 2.45 GHz (5W), the current density of the COMIC source can reached 10 mA/cm².

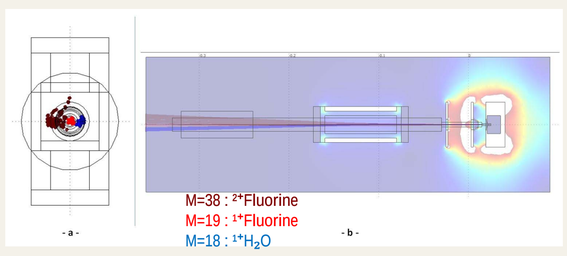


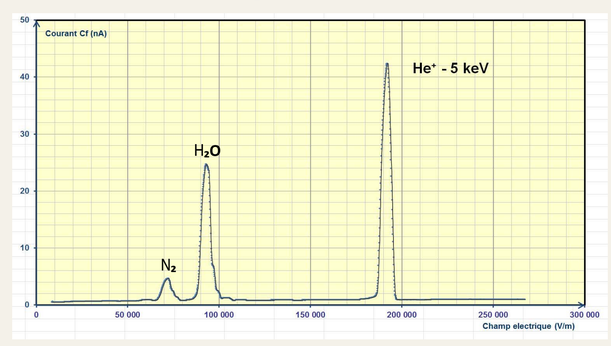


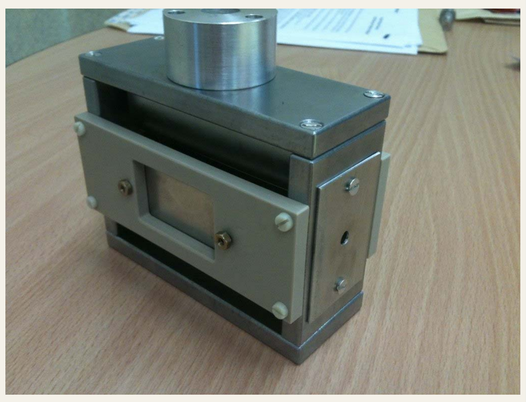
Courtesy of P.Sortais, T.Lamy.

The Wien filter

The Wien filter is designed to make a **q/m** separation of ions. It is the combination of a 0,36 Tesla vertical magnetic field and a 3,3 kV/cm horizontal electric field which can be tuned to select the desired ion beam

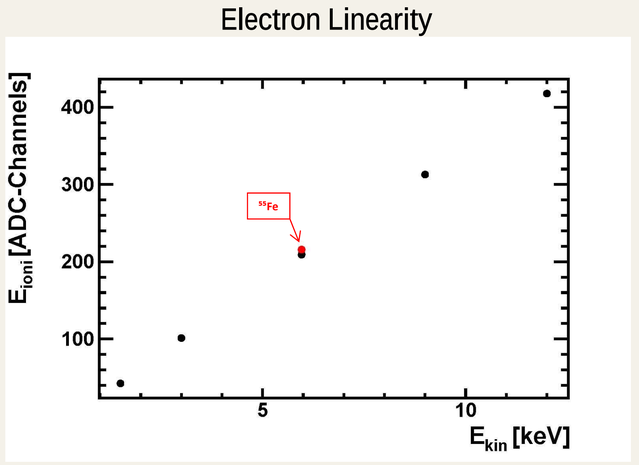




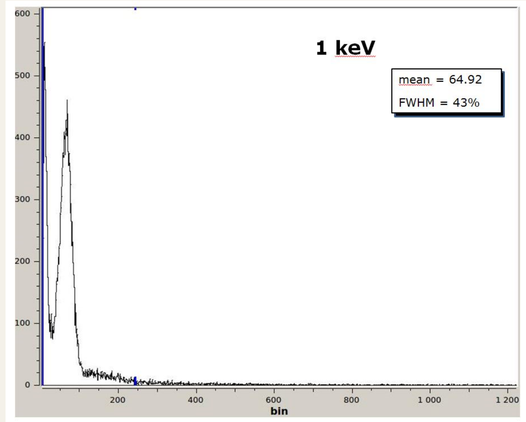


Electron response

Electron Linearity



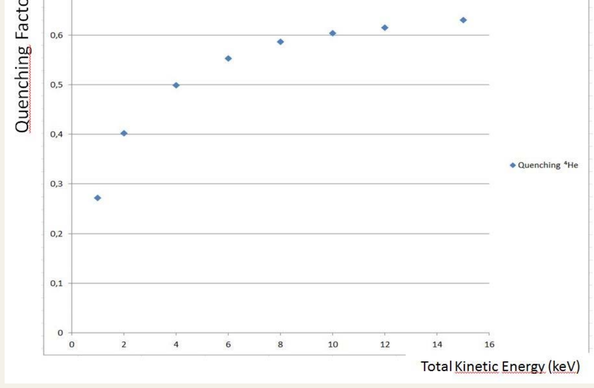
1 keV Electron



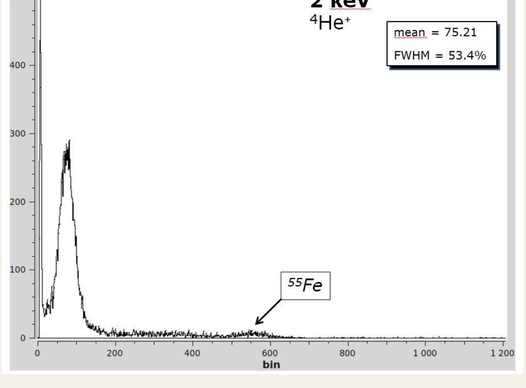
The linearity response shows that the electrons do not quench for energies above 100 eV

Ionization Quenching Factor measurement

Helium IQF curve



2 keV $^4He^+$ spectrum



The IQF curve shows the ratio of the measured ionization energy compared to the initial kinetic energy

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

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