IONIZATION EFFICIENCY OF A COMIC ION SOURCE EQUIPPED WITH A QUARTZ PLASMA CHAMBER

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Abstract

Increased ionization efficiencies of light noble gases and molecules are required for new physics experiments in present and future radioactive ion beam facilities. In order to improve these beams, a new COMIC-type ion source with fully quartz made plasma chamber was tested. The beam current stability is typically better than 1 % and beams are easily reproducible. Highest efficiency for xenon is about 15 %. However, the main goal is produce molecular beam including radioactive carbon (in CO or CO_2), in which case the efficiency was measured to be only about 0.2 %.

Q-COMIC

The new COMIC source (see figs. 1 - 5) designed by LPSC/Grenoble incorporates special features such as a plasma chamber fully made of quartz (Q-COMIC), which should provide chemically favorable conditions for molecular ion beam production, especially for CO_2. The source is placed inside a standard ISOLDE target base (fig. 6), in vacuum. In this prototype unit the gas of interest (simulating a radioactive gas from target) is injected through a calibrated leak of 3.3E-6 mbarl/s (value corresponding air). The buffer gas is injected into the system by using a Pfeiffer EVR116 gas dosing valve.

Figure 7 shows a summary of the gas efficiencies as a function of mass. All the measurements, except CO_2, fit very well on the dashed trend curve. It seems that the higher masses are ionized and extracted more efficiently than lower masses. This behavior looks very similar to the kinetic theory of gases where $v_{rms} \propto \sqrt{(1/M)}$.

Figure 8 shows efficiencies plotted as a function of the first ionization potential of the ion. Also in this case CO_2 does not follow the tendency of the other tested gases. Possible explanation is that the CO_2 molecule is breaking in the plasma (C=O bond energy is only 8.3 eV). This was studied by measuring the CO_2 and C ion production as a function of microwave power (fig. 10).

The next step will be using oxygen (O_2) as a buffer gas, which is expected to improve C + O_2 recombination and therefore the CO_2 beam production.

Buffer gas	CO_2 gas efficiency
Argon	0.09 %
Krypton	0.12 %
Xenon	0.22 %

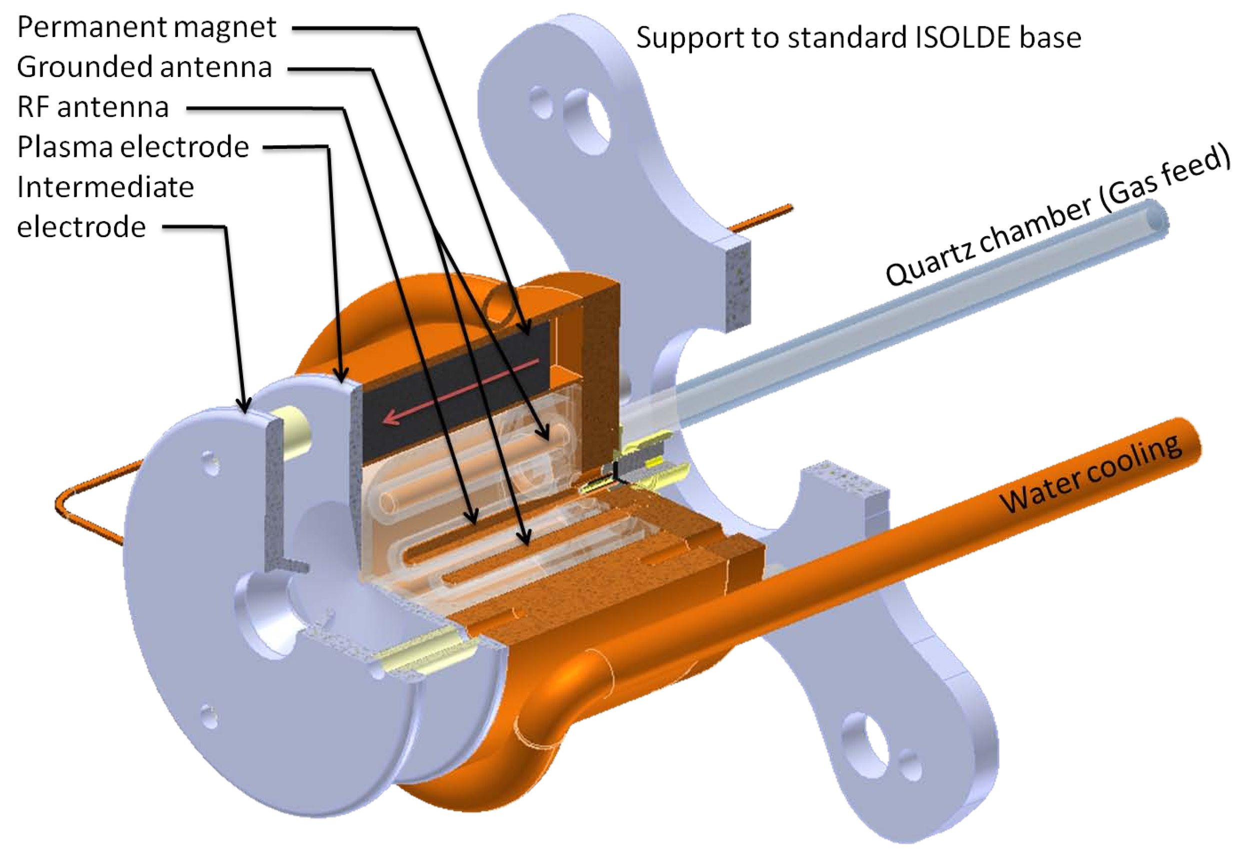

FIG. 1. Schematic of Q-COMIC

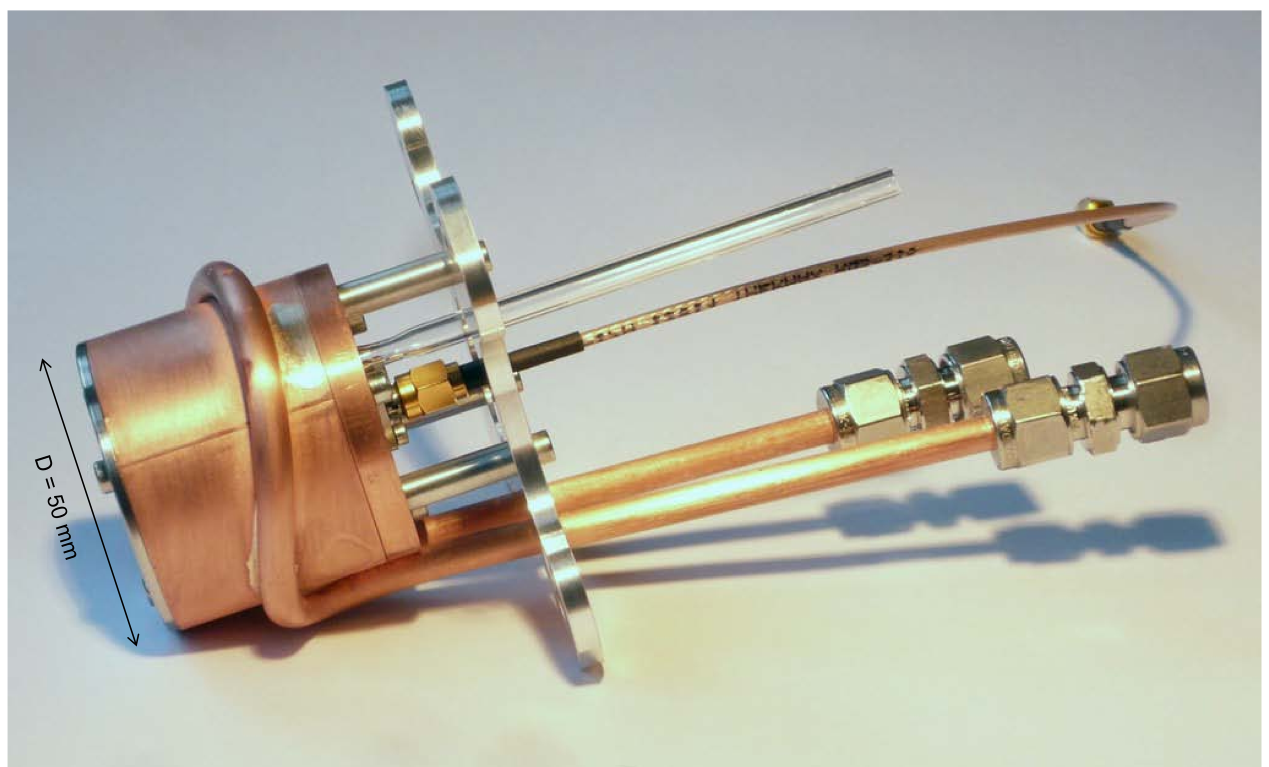

FIG. 2. Q-COMIC

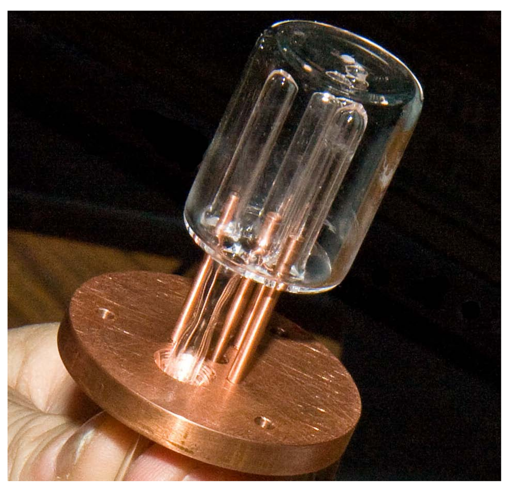

FIG. 3. Quartz chamber

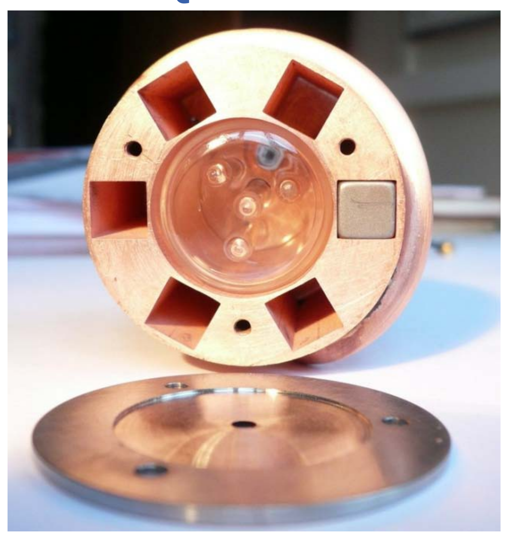

FIG. 4. Parts inside

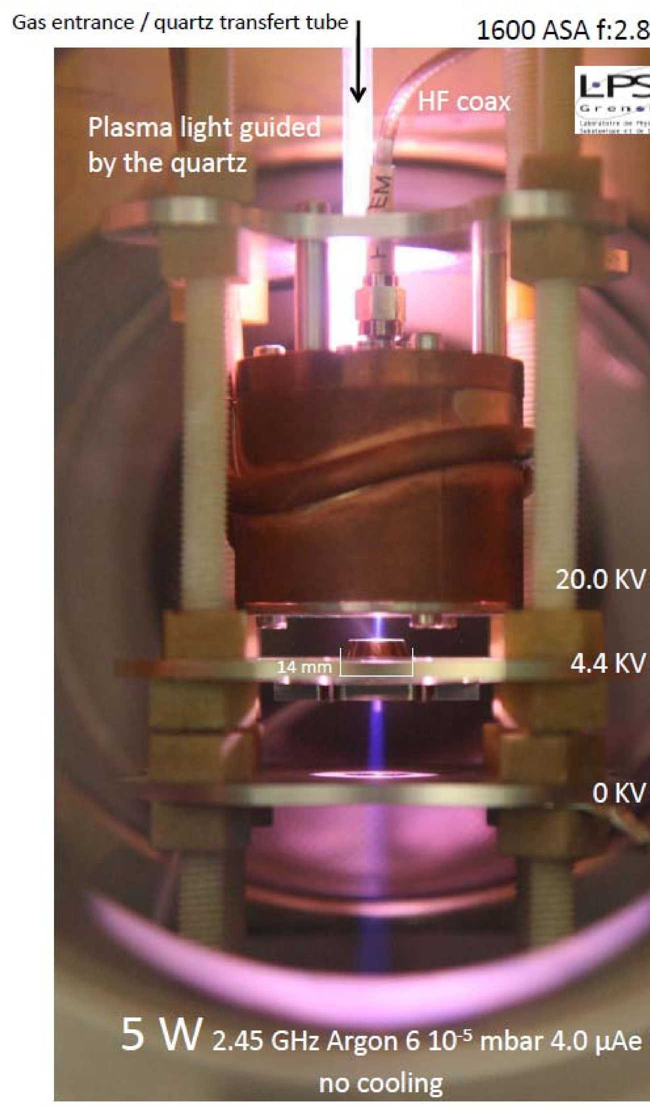

FIG. 5. Beam

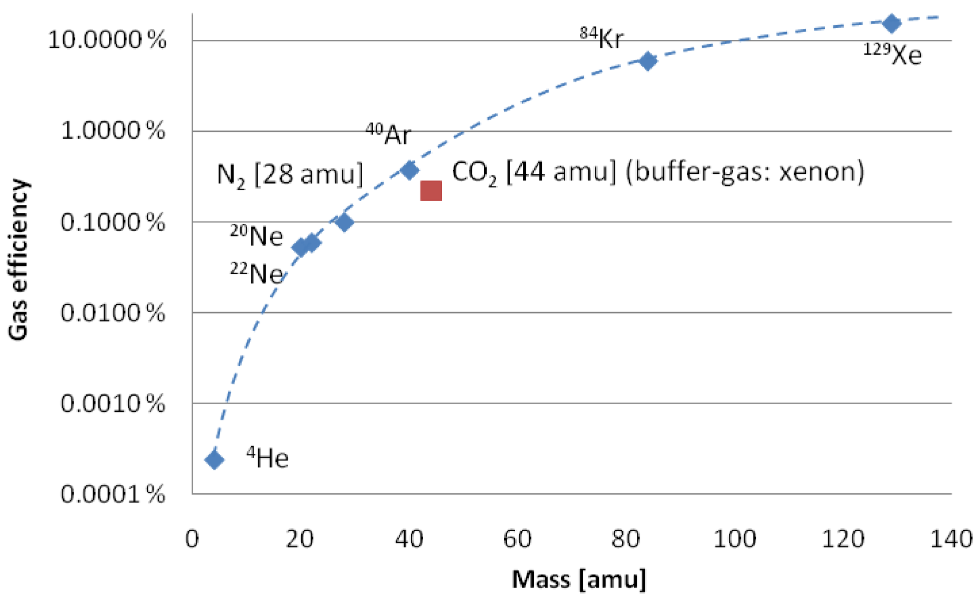

FIG. 7. Summary of the measured gas efficiencies

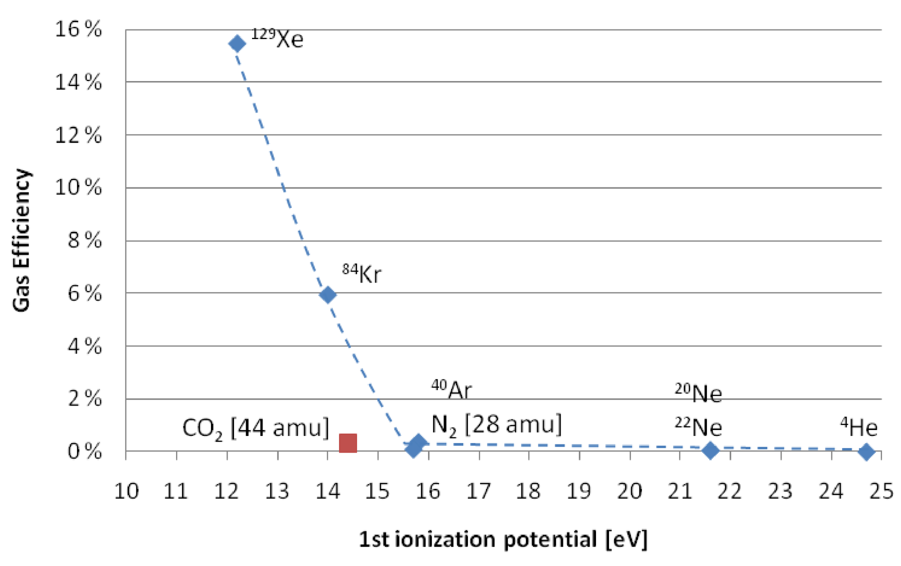

FIG. 8. Gas efficiency as a function of the first ionization potential

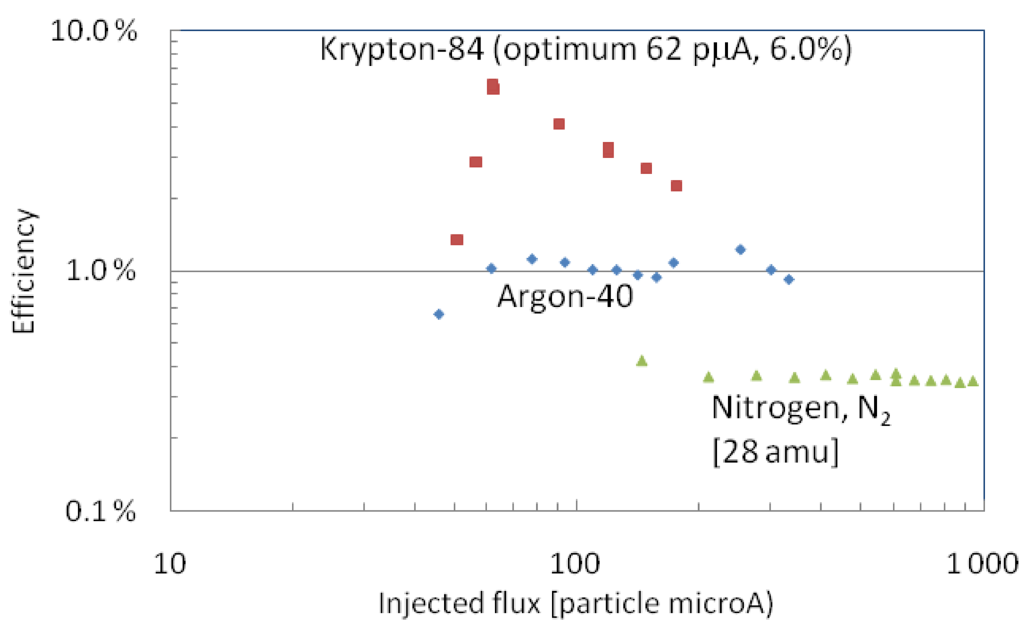

FIG. 9. Gas efficiency as a function of the injected flux

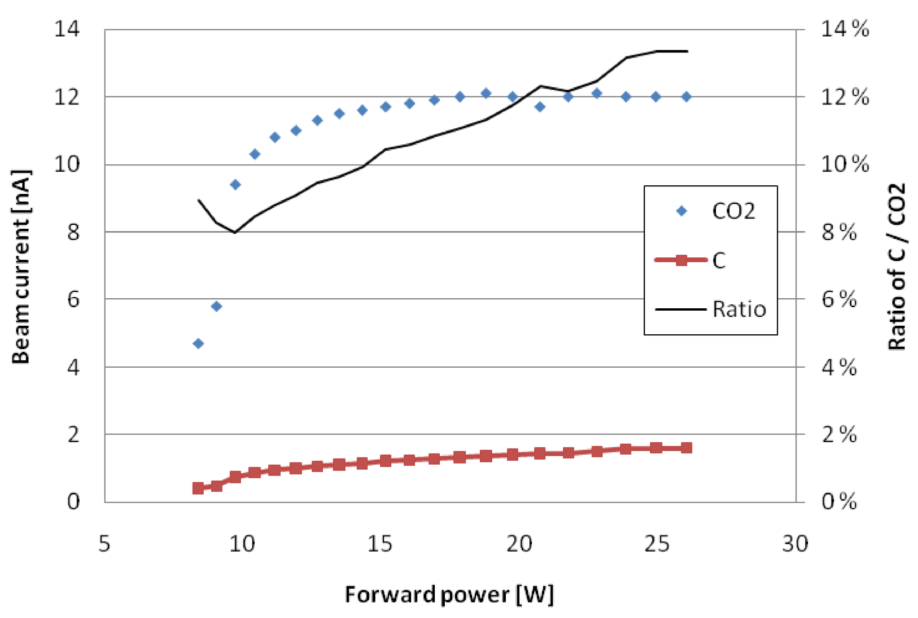

FIG. 10. CO_2 breaking to C

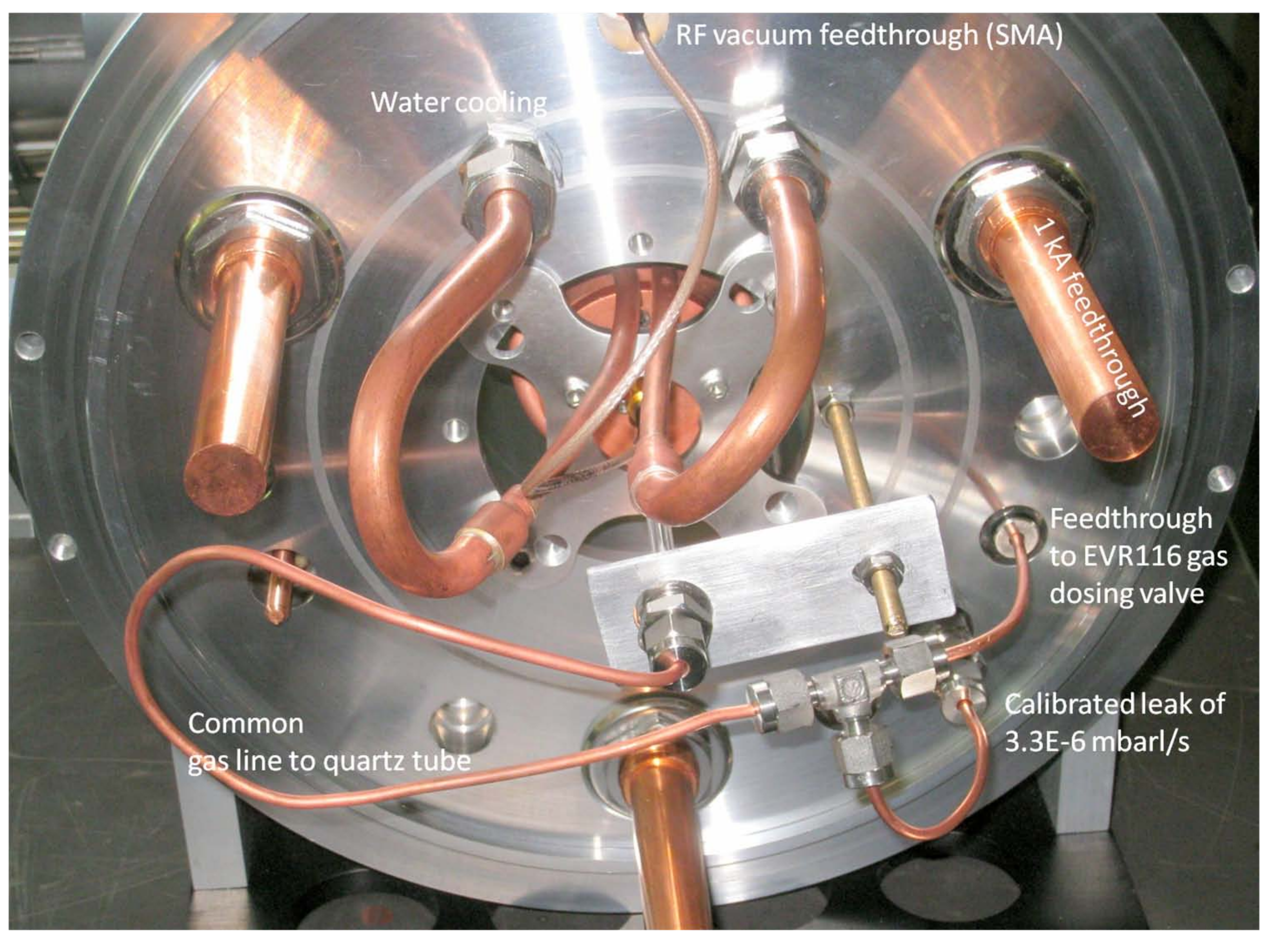

FIG. 6. Q-COMIC setup and gas injection system

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