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SENSITIVE MEASUREMENT OF KRYPTON USING RESONANCE IONIZATION SPECTROSCOPY*

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Since the detection of a small number of ^{81}Kr atoms (<1000) is very important for groundwater dating, polar ice cap dating, nuclear waste disposal, and solar neutrino research, we are developing a method for counting krypton with isotopic selectivity. The ultimate goal is to count a small number of selected atoms (~100), even when mixed with 10^{12} or more atoms of the adjacent isotope. The experimental schematic is shown in Fig. 1. The concept for counting noble gas atoms with isotope selectivity is to utilize a laser for producing ions from atomic number (Z) selected atoms and a mass spectrometer for atomic mass (A) selection. After atoms have been Z and A selected, the ions are accelerated to a few kilovolts onto a target where implantation occurs. Suitable targets will emit a pulse of several electrons each time that the selected ions are implanted. An electron multiplier is used with sufficient gain to count each implanted ion from the electrons emitted by the target. In our quadrupole mass spectrometer the rejection ratio for neighboring masses is only about 10^4. Thus, the krypton atoms implanted in the target must be released and run through the mass filter again. For example, a sample containing 10^8 krypton atoms and ~1000

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^{81}Kr atoms will have to be cycled twice through the machine. The first time through, 10^7 atoms of ^{82}Kr would give 10^3 counts which is comparable to the number of counts from ^{81}Kr. If the gaseous part of the sample is pumped out and the implanted krypton atoms are released, there will be 1000 ^{81}Kr atoms and 1000 ^{82}Kr atoms in the chamber. On the next cycle of this process, the contribution of ^{82}Kr can be neglected.

There are no commercially available lasers to do efficient selective excitation of krypton. A four-wave mixing scheme was used to generate 1164.9 Å laser beams with energies of 500 nJ/pulse. Thus, krypton atoms can be efficiently excited and subsequently ionized. The laser scheme for generating tunable vacuum ultraviolet laser beams around 1165 Å is shown in Fig. 2. Finally, an "atom buncher" is provided to enhance the probability that krypton atoms will be in the laser beam at the time of the laser pulse. In brief, in order to count a small number of isotope-selected krypton routinely, the following conditions must be met:

1. The rate of outgassing of krypton atoms from the chamber must be less than 10^5/min.

2. All surfaces must be clean to prevent krypton from sticking to the wall of the chamber.

3. A laser scheme for the efficient and selective ionization of krypton is required.

4. An "atom buncher" to enhance the ionization efficiency is needed.

5. A target with high yield of secondary electrons to get 100% counting efficiency is desirable.

6. A target that will release all of the krypton atoms is essential.

Nearly all of the above requirements have been proven by independent experimental work. The experimental details will be presented. Development of a complete setup to count very low levels of selected krypton isotopes is currently in progress.

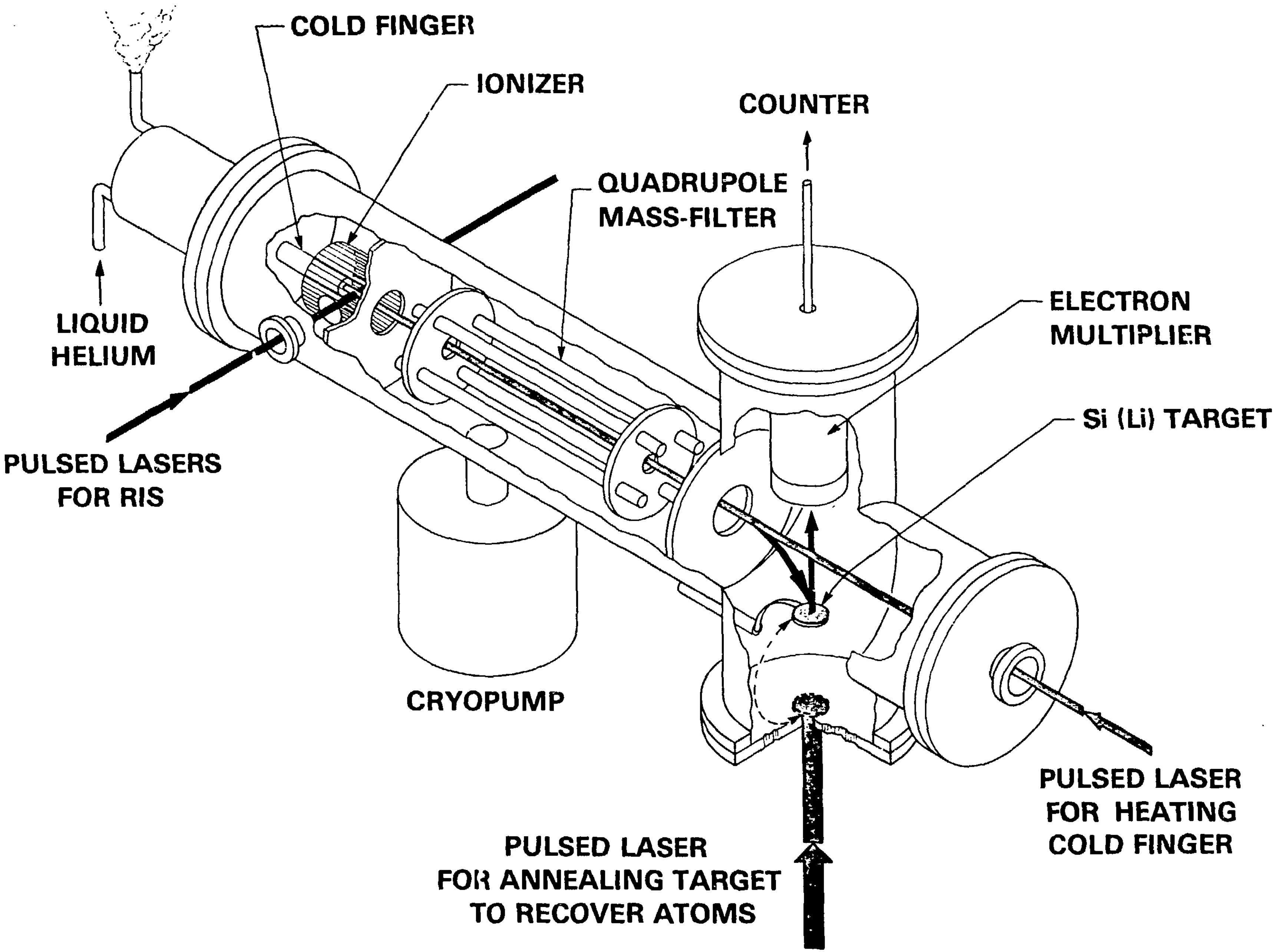
COLD FINGER
IONIZER
COUNTER
QUADRUPOLE
MASS-FILTER
ELECTRON
MULTIPLIER
LIQUID
HELIUM
Si (Li) TARGET
PULSED LASERS
FOR RIS
CRYOPUMP
PULSED LASER
FOR HEATING
COLD FINGER
PULSED LASER
FOR ANNEALING TARGET
TO RECOVER ATOMS

Fig. 1

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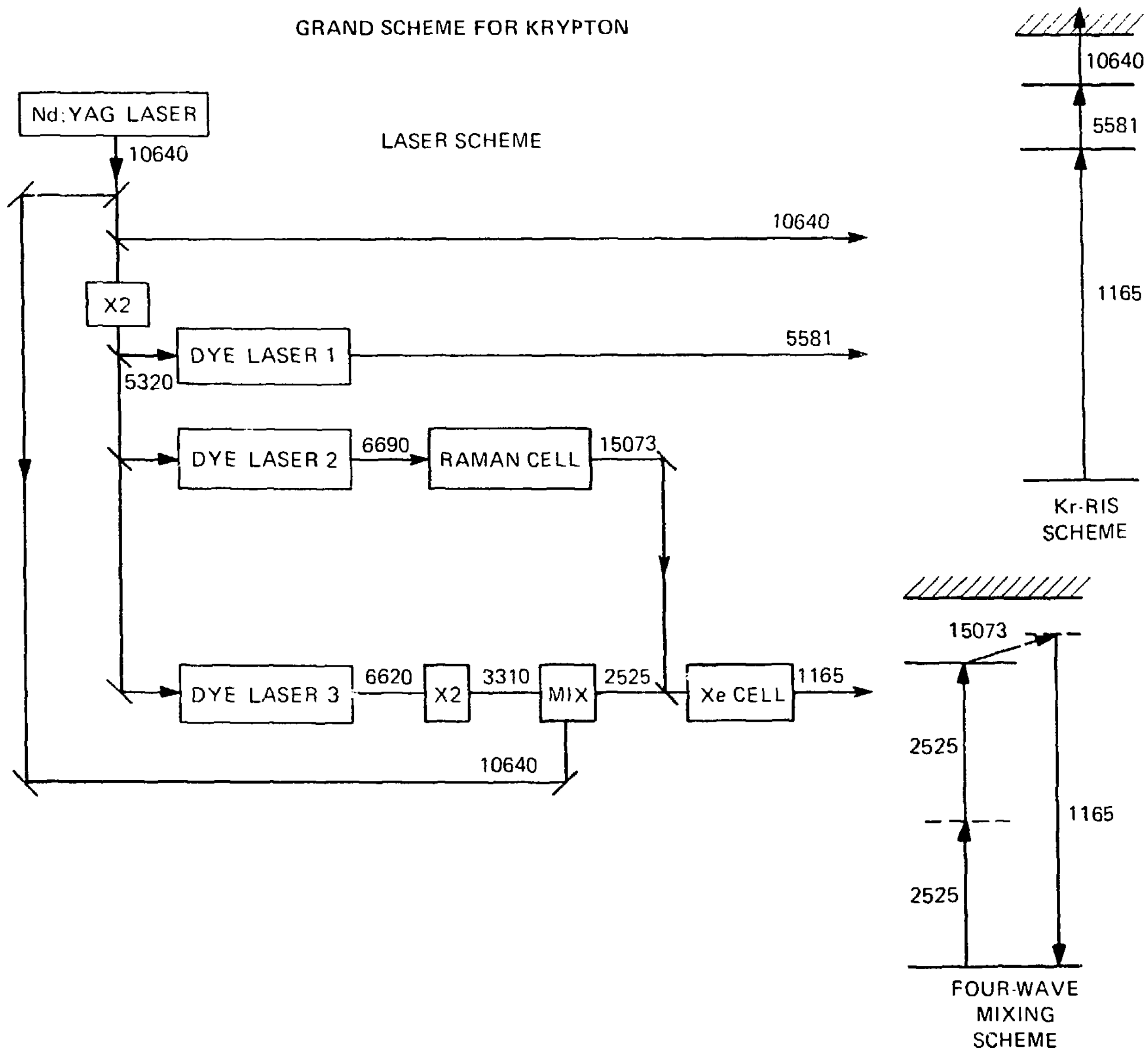

Fig. 2