the presence of a single atom of an unwanted material, such as iron, can disrupt reliable performance. Hence, as a means of improving their products and manufacturing processes, makers of such devices are keenly interested in scientific instruments that can detect and characterize impurities on this most fundamental of scales.

Counting atoms is also important to the study of geology, minerals science, hydrology and natural history. Predictive models of slowly migrating water in underground aquifers, for example, may be validated by age dating techniques that rely on measuring minute amounts of a noble gas (krypton). The same is true for understanding the earth's long term climate cycles, as evidenced by the same noble gas trapped in deep cores of permanently frozen antarctic ice. In both cases, not only must the gases be identified and isolated, but individual subdivisions (isotopes) within their own atomic species must be sorted out and counted precisely.

In the climate cycles research, standard techniques require as much as one thousand tons of antarctic ice to determine a single data point in time. With the RIS technique, a pound or two may now suffice. Similarly, the Shroud of Turin, believed to be the burial cloth of Christ, has never been scientifically dated because previously existing dating techniques would have damaged or destroyed an unacceptable amount of material. Hence, with the advent of RIS, size dependent constraints such as these may vanish altogether.

In another class of applications, RIS affords new opportunities to search for rare events of great interest. Such events, if they could be detected reliably, might confirm certain theories about the processes of the sun, which involve the measurement of solar neutrinos. Or, they may lend support to the grand unification theory of the basic forces of nature, a clue to which may be gleaned from observing the so-called process of a "double beta" decay.

In both cases, experiments involve the detection and monitoring of extremely rare events. In a proposed solar neutrino experiment, for example, only 100 atoms of krypton-81 are expected to be produced in a tank containing 100,000 gallons of ethylene bromine over a period of 6 months, each one of which needs to be detected.

The RIS technique of detecting, sorting, and counting such small amounts of highly specified atoms is an extraordinary technological feat. In reality, the machines that perform the work constitute a unique configuration of some of the very latest advances in laboratory equipment and scientific instrumentation.

Today, an experiment making full use of RIS capabilities is likely to employ a large complement of hardware. This could include ultraclean containment vessels, powerful vacuum pumps (which for cleanliness purposes use no oil whatsoever), highly sensitive counters; and signal amplifiers. It might also include electromagnetic devices that filter out unwanted particles; cryogenic probes that "bunch" atoms together via condensation at temperatures of only a few degrees above absolute zero; other devices that manipulate atoms to strike a receiving plate, implanting them for temporary storage (see Ion Implantation); and still others that release them upon demand for further analysis (see Laser Annealing).

The ingenious exploitation of all these capabilities and their assembly into a compact and efficient instrument was the successful outcome of the 1978 and 1982 Seed Money projects. The 1978 project applied the RIS technique and much of the above hardware to the study of surfaces of solids. The 1982 project focused on the measurement of rare atoms in the medium of gas. Both broke new ground.

It was the 1975 Seed Money project, however, in which the heart of the RIS technique was developed. This involved the use of lasers in combination with a developing field of science called photophysics. Lasers are electrically powered devices that emit intense beams of highly coherent and finely controlled light. Photophysics is the study of how light interacts with matter and, in particular, with the atoms of matter and their orbiting subatomic particles, called electrons.

An example of how light and matter interact may be recalled by what happens to ordinary table salt when it is tossed into a flame. A rainbow of colors is immediately given off. The colored light arises from the heat of the flame, which causes certain electrons in the atoms of the salt to become momentarily excited. This increases their energy and lifts them temporarily into higher but unstable orbits, called excited energy states.

After a brief moment, they collapse back to their lower and more normal orbits, called ground states. During the downward transition, however, the extra energy of the excited state is released to the environment, and seen by the human eye as a perfectly pure emission of colored light.

As it happens, the color of the light is like a fingerprint or signature. Each color may be uniquely associated with each type of electron transition for each type of atom.

In 1975 Seed Money researchers hypothesized that, with the advent of tunable lasers, they might be able to reverse this process and use it to their advantage. That is, they would try to tune laser light to the exact color recognized only by the selected electron transition associated with the atom of interest.

Using the laser, they proposed to pump in just enough light energy to hit the right electron and lift it up to a preselected excited state, wherein it is more loosely bound to the atom's nucleus than when it is in the ground state. Then, while the electron was vulnerable, they would hit it again to remove the electron altogether. If they could remove the electron, which is