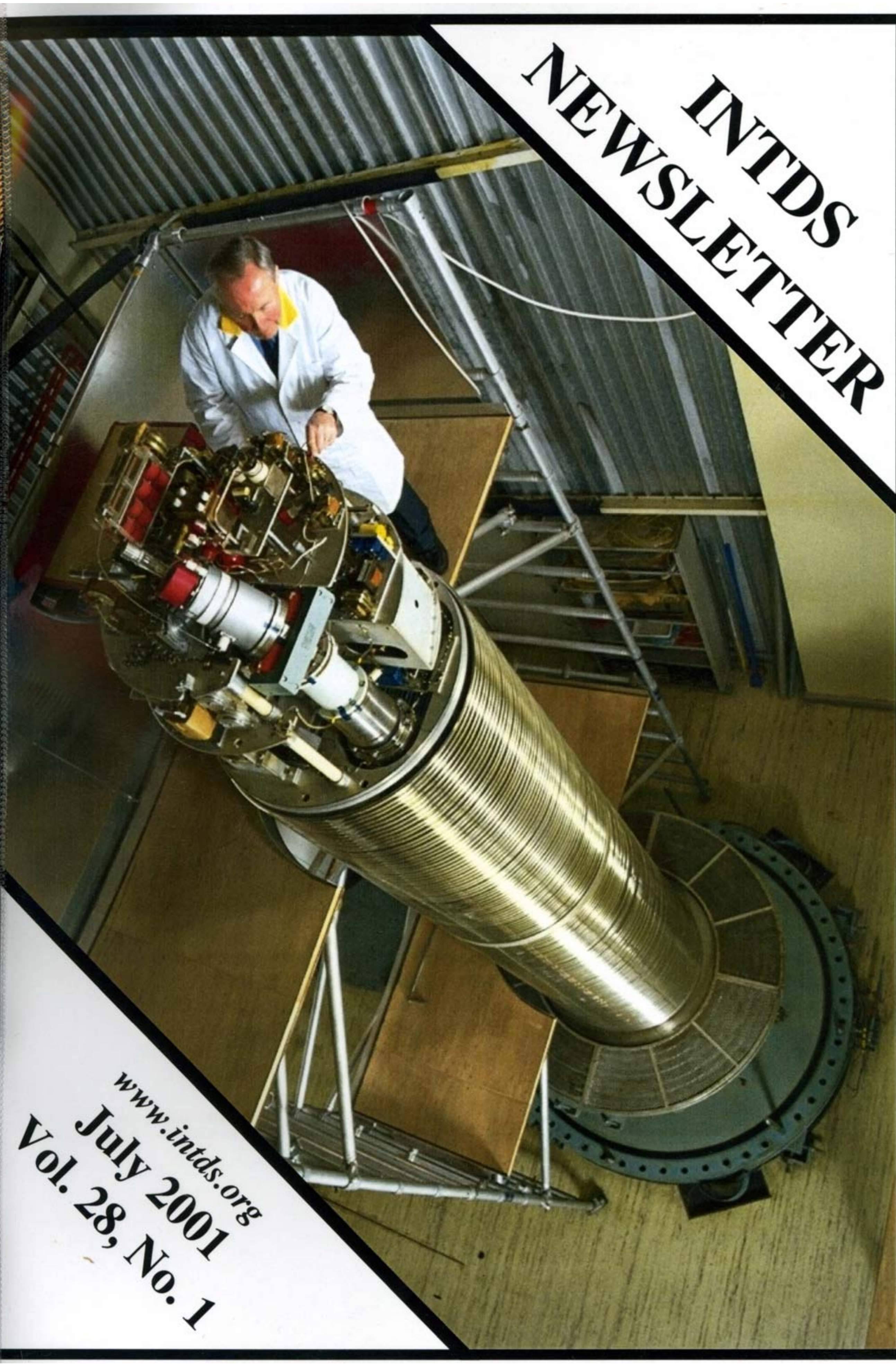
INTDS NEWSLETTER



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Cover picture: Albert Crametz working on the 7 mV van de Graaff accelerator at IRMM, for deuteron and α-particle acceleration for the production of monoenergetic neutrons (1 - 24 meV) by bombardment of deuterium or tritium targets.

Editor’s note

I am very sorry to have to report the death of one of our members, David Blunt, on June 10, 2001. David was the target maker of the Schuster laboratory of the University of Manchester before he retired in May 1997. His contributions to INTDS proceedings included work on thin, metallised polymer foils for detector windows and thin, isotopic metal foils.

David was a natural adventurer, who made strong and lasting friendships wherever he went. He loved big projects and this drew him to his farm in France, which he transformed from a dilapidated house into a home. He integrated himself into the whole community, from playing football for the veterans team to helping out on the land, and this lead to a great deal of affection between him and his close neighbours.

Our condolences go to Susan and to his sons Gareth and Graham. David was known and respected by many INTDS members and we are very sad to have lost him.

Production of self-supporting wedge-shaped Al-degraders for the heavy-element program

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Introduction:
For the heavy element program at GSI the electromagnetic separator SHIP is applied. The heavy-ion beam interacts with the target nuclei and due to momentum conservation the reaction products fly in forward direction and are separated in-flight from the primary beam by means of electric and magnetic fields. Due to the geometry of the separator set-up the background is asymmetric in horizontal direction. To reduce the background that reaches the detectors degrader foils made of Mylar were used. But since the degraders decelerate the evaporation residues as well as the background particles the thickness of the degraders has to be chosen with care. If the heavy-element nuclei are not implanted deeply enough into the silicon detector escaping-alphas may be lost and the decay chain necessary for the identification of the element is incomplete.

Improvement:
To enhance the signal-to-background ratio more effectively without reducing the implantation depth for the residual nuclei too much an asymmetric degrader is developed. These degrader foils are thicker at the end where the background is more intense and thinner at the opposite end. Depending on the studied reaction, different thickness gradients are desirable.

The sheets out of float glass on which the aluminum is evaporated has to be cleaned very carefully mechanically and additionally by glow discharge inside of the recipient directly before the coating. As a water-soluble interlayer 50 nm to 100 nm CsJ are thermally evaporated on the freshly cleaned surface from a Ta-boat. In the same process the aluminum is evaporated from an intermetallic crucible by means of an electron-beam from an electron-gun. It is crucial to float the layer very slowly from the glass sheets since they tear quite easily because of their considerable weight. The floating foils are then fetched carefully with the degrader frames which have a total area of 50 mm x 90 mm.

To get layers in different thickness and with different thickness gradients we investigated the influence of the following parameters:

1. evaporation velocity,
2. fill level of the crucible,
3. vertical distance between glass sheet and crucible,
4. angle of inclination of the glass sheet relative to the horizontal position and
5. asymmetric horizontal positioning of the glass sheet relative to the crucible orifice.

The results of our investigation are the following:
We vary all of the parameters and after each variation the prepared foil is cut into squares of 1 cm² and each is weighed out separately. An example of such an evaluation is shown in figure 1 where the thickness distribution is plotted versus the area of the foil.
The evaporation velocity is chosen to about 15 µg/s·cm², which is as fast as possible without a spraying of the melt. When the evaporation velocity is too low the foils get too much tensions and, what is more important, the gradient gets more and more nonlinear. Nevertheless in a

small range the evaporation velocity can be varied and a higher velocity results in a steeper increase of the thickness.
The fill level turns out to be very important. The evaporation cone has to be as wide as possible and it has to be kept as constant as possible during the whole evaporation process in order to get the necessary lateral homogeneity of the thickness gradient. That means that the orifice of the crucible should be big and the crucible has to be filled as high as possible with aluminum. Filling the crucible to more than ¾ is not advisable since already there the melt begins to creep out of the crucible. We use a total portion of aluminum of approximately 4 g in the beginning and the rest portion after the evaporation should not be lower than about 2.5 g. The crucible chosen has an orifice of about 1.7 cm in diameter. Additionally the electron-beam spot is wobbled with 8 Hz in X and Y direction to guaranty a steady heating of the whole surface of the melt.

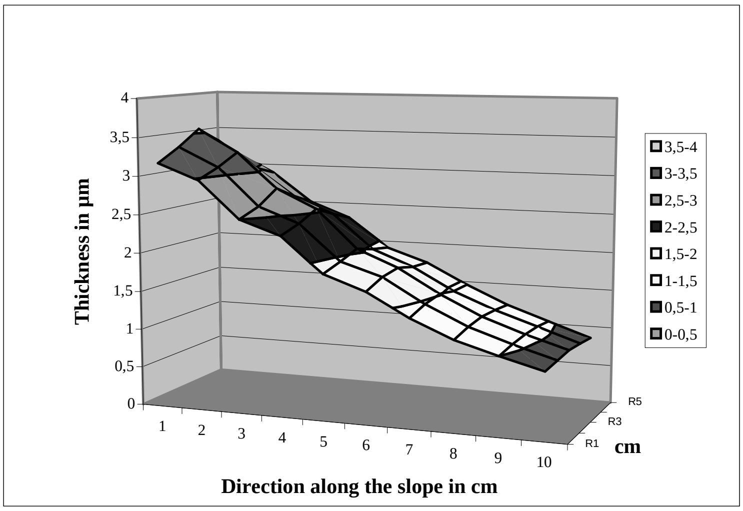

Figure 1: Thickness distribution of one aluminum foil determined by weighing the cut parts with 1 cm² area each.

The glass sheet has to be positioned as asymmetric as possible that means with the one end directly above the orifice. The vertical distance between crucible and the lowest part of the glass sheet is varied from around 105 mm up to125 mm.
The inclination angle also influences the gradient but to a smaller extend compared to that of the vertical distance. If the angle is too small again the slope will become nonlinear. For the real production we keep the angle constant to about 20°.
By varying the total evaporation time the absolute thickness of the thinner side can be set while keeping the total gradient unchanged. The thin end should begin with a thickness as small as possible so we choose it to about 0.5 µm since for thinner layers the durability during the floating and fetching process is too poor and also the handling of the degraders gets very difficult. For this thickness it takes an evaporation time of about 3 min.

Figure 2 shows the different thickness gradients we are able to prepare for some selected foils. All self-supporting foils are prepared on glass sheets with a total length of 11 cm so that one cm on both sides of each foil can be weighed out carefully. Together with the total areal weight of the remaining foil we get three measured data points and the linear fit of these points gives us a measure for the thickness gradient for the foil we give away.

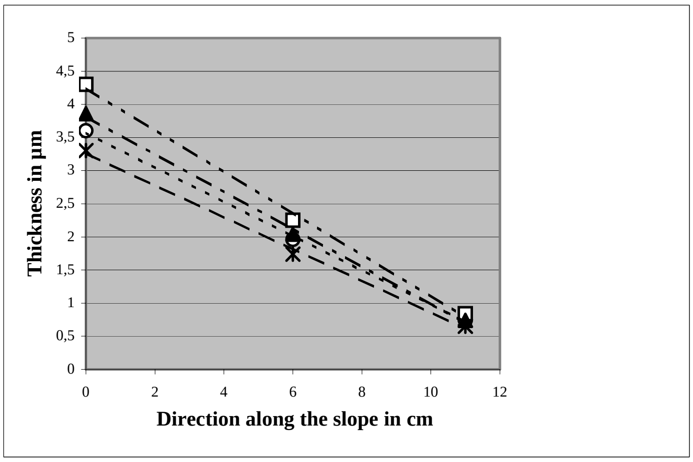

Figure 2: Measured thickness and linear fit for four Al-foils with different thickness gradients.

We also prepare degraders with 2 µm thick Mylar-foils as backing. In those cases the aluminum is directly evaporated on the Mylar which was already glued on the frames. The other conditions are the same as described above. We prefer the self-supporting version of the degraders since the Mylar is only one more additional material in the beam and it tends to wrinkle because its getting too hot during the evaporation process.

ISOTOPE PRODUCTION: THE EXPECTED CHANGES

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Abstract

Until recently, in economically developed countries, the volume of stable isotopes consumed was a reliable indicator of dynamism in many branches of science and technology. Prudent application of stable and radioactive isotopes allowed numerous investigations and techniques to become simpler, and more cost effective. Some medical examinations would be impossible without the aid of isotopes. Nevertheless, public protests and calls for complete-or almost-complete interdiction of their long-term use, in favor of the development of computer technologies have occurred. The result may be a sharp reduction in production demand for stable isotopes, radio-pharmaceuticals and other radioisotopes. Thus, the beginning of the 21st century can become the end of a traditional isotope production. It is possible to speculate that isotope production will be mainly a short list of stable isotopes produced in large lots. Examples of this list could be depleted zinc for nuclear power, isotopically pure silicon for microelectronics, some isotopes of cadmium for production of laser engineering, etc.

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Discussion

It is possible to forecast in the next years essential changes in the structure of production and consumption of stable isotopes. The last decades of the 20th century were characterized by increasingly wide application of isotopes, including stable ones, in different fields of science and engineering. It is difficult to find a field of human activity where isotopes would not be used to some extent. A considerable number of stable isotopes were used as starting materials for the production of radioactive isotopes intended for medicine and various branches of industry, for example: to detect defects in metals and other materials and items.

The broad prevalence and development of analytic procedures and devices that use radioisotopes was connected primarily with the penetrating ability of ionising radiations and the relative simplicity of their detection and precise measurement. The extremely wide range of nuclear and physical properties of isotopes (both initially stable isotopes and radioisotopes are produced by irradiation of targets by neutron or proton beams in cyclotrons and nuclear reactors) allowed one to select a type of radiation and energy necessary for deriving of a clear image of a structure of substance or interior organ of an alive organism at using relatively simple and cheap procedures without inflicting appreciable damage on analysable object (alive or lifeless).

Any other known procedures of the non-destructive analysis of lifeless substations and objects or diagnostic examinations of alive organisms either did not allow to obtain a precise image of an interior structure because of a high screening capacity of outside surfaces and feeble relation signal / noise, or were extremely expensive owing to the application of the complicated and expensive equipment and complexity and duration of measuring.

Till the last time the change of dynamic of stable isotopes consumption was the reliable indicator of the development of a relevant branch in the economically developed countries. The application of stable and radioactive isotopes allowed essentially to simplify and to make cheaper many technologies and investigations. The realization of some medical examinations would be impossible in general without isotopes.

For example, according to the Department of Energy of the USA, in the middle of the ninetieth application of isotopes in medicine only saved up for economy of the USA about 12 billions of dollars annually [1]. It is the huge sum even for such economic giant as the USA.

The protests against the production and the application of radioactive materials (and in the long term – complete interdiction of their usage, for example, in medicine) had no noticeable results many years because of the absence of an actual alternative to radioisotope methods of the examinations and diagnostics. To make the changes happening per the last years clearer, we should mention that these protests were bound up mainly not so much with an application of the radioisotope sources (*i.e.* harmful consequences of their application for the people – both working staff and population – and environment), as with production of radioisotope materials and a problem of a storage of a permanently accruing radioactive waste.

Experience of an operation with sources of ionising radiations that has been accumulating during many years and the numerous biological and medical researches have allowed to reduce to negligible minimum a probable harm inflicted both to the patients and staff working with radioisotope substances and diagnostic apparatuses. (It is necessary to mention that during last years some new data were obtained concerning small radiation doses considered practically safe earlier. Under certain circumstances, they are capable to inflict considerably more serious consequences for an alive organism than higher doses. Probably, the existing now permissible levels and doses of ionising radiations should be reconsidered. However, this problem is not investigated completely and more precise information is not available.)

The noticeable quantity of a radioactive waste with different levels of a specific activity and half-life periods is generated during production of the radioisotope substances and utilization of spent radioisotope sources. The problem of their safe and cheap destruction does not have any acceptable solution till now. Their amount (both volume and aggregate activity), certainly, is not comparable to the amount of a waste accruing as result of exploitation of numerous energy and transport nuclear reactors all over the world. Therefore, they, one would think, do not represent a special problem as against a blanket problem of a burial of radioactive waste – by the way, this problem does not have good-enough solution till now.

However very wide expansion of the radioisotope devices and procedures in the last decades and rather small specific activity of this sources created considerable problems, bound with necessity of making and maintaining of a high-reliable system of the delivery of the radioactive sources and standards to thousands organizations, enterprises, hospitals, *etc.*, and collecting, sorting and storage (or burial) the same quantity of spent sources unsuitable to further exploitation. Passing over a problem of the costs of the maintenance of the operation of this system, it should be mentioned that the increasing of the distribution of the radioisotope devices and diagnostics gives as a result that less qualified staff will be recruited to operate with them. It increases sharply the potential danger of a different sort of accidents with radioactive materials.

The latter is topical for less developed countries especially, where organizations, enterprises and hospitals are restricted frequently in opportunities of tutoring or hiring of sufficient number of the competent specialists. However, accidents caused by an improper or negligent use or storage of radioactive sources and substances, errors of staff, *etc*., also happened and will happen in high-developed countries with a traditionally high culture of labour too.

It is not necessary to remind of magnification of opportunities for ill-intentioned using of radioactive materials (for example, in acts of terrorism) together with an expansion of the application of the radioactive materials in different fields of activity and different countries of the world.

Therefore it is natural these problems were permanently under consideration of a public all over the world many years. However, there was no reasonable alternative to application of the radioisotope devices and procedures until recently.

The situation has changed essentially last years. Rapid progress of computer technologies can result in a sharp reduction of a necessity in stable isotopes used as start materials for producing radiopharmaceutical and other radioisotopes.

The main part of the medical isotopes is used now in the diagnostic purposes. The physical properties of the medical radioisotopes allow to carry out diagnostics of many internals and diseases without considerable harm to health of the patient, using thus rather simple and cheap diagnostic equipment. The application of the radioisotopes in therapy (i.e. there, where exactly ionising radiation is used as the medical instrument and consequently is not only inevitable, but necessary) has not received such wide circulation, as in diagnostics till now.

In the last years the fast development of microprocessor engineering and software has been resulting in annual tenfold growth of the computational capability of simple enough and cheap computer systems. There is no problem now for reliable detection of a signal at a ratio of levels signal / noise as 1:1000 and even 1:10000. That is enough for use in the diagnostic purposes relatively coarse and low-sensitivity detectors and methods of diagnostics – ultrasonic, thermal, *etc*.

Naturally, the rapid progress of the computer technologies permitting to do without radioactive substances and harmful and potentially dangerous consequences of their application could not remain without attention of medical diagnostic equipment producers.

For example, Cadwell Laboratories have begun production of the diagnostic devices for diagnostics of internal, such as, cordial muscle, with use of ultrasonic sensors [2]. Such examinations could be conducted only with the use of medications based on a radioisotope Tl-201 till recently. Thus, volume of received information is much higher, than at a realization of the diagnostics with the use of the radioisotopes, and the time of survey is much less. If to take into account the fact, that the prices of these devices are comparable to the prices of usual personal computers, it is clear, that the re-equipment of the leading clinics and hospitals (and, accordingly, complete failure to use radio-pharmaceutical) is inevitable. It is only a matter of time. A similar situation is in a production of devices for materials technology, such as defectoscopes.

It is possible to find some analogy of the beginning changes in application of the isotopes and transition from sensitivity and precision enhancement of the direct measurements to a computer processing of the results obtained by means of rough enough and inexact measuring, in such far area as a space photo. Many years it has been developing by means of a direct perfecting of optical systems for deriving the images of the earth and different objects in more and more high resolution. However already in the middle of the ninetieth, the further image enhancement of space photos became practically impossible owing to natural restrictions superimposed by the laws of geometrical optics. Unsolvable, it should seem, problem was solved simply and elegantly by an application of computer processing of series of snapshots of the same object (or region of a surface) with the low resolution gained with the help of rather simple and cheap optics in different frequencies of a spectrum.

Apparently, it is possible to expect a sharp reduction of necessity in stable isotopes used now as start materials for the production of radioisotopes in the nearest years.

The first signs of inceptive serious changes of an isotopes consumption structure and decrease of their application field (for the first time after many years) have begun to appear already some years ago. According to the information of the Department of Energy of the USA, in 1995 47 % of the stable isotopes and 13 % of the radioactive isotopes produced by the American manufacturers were used in research and development works [1]. Two years later, in 1997, these numerals decreased up to 33 % and 4 % only [3].

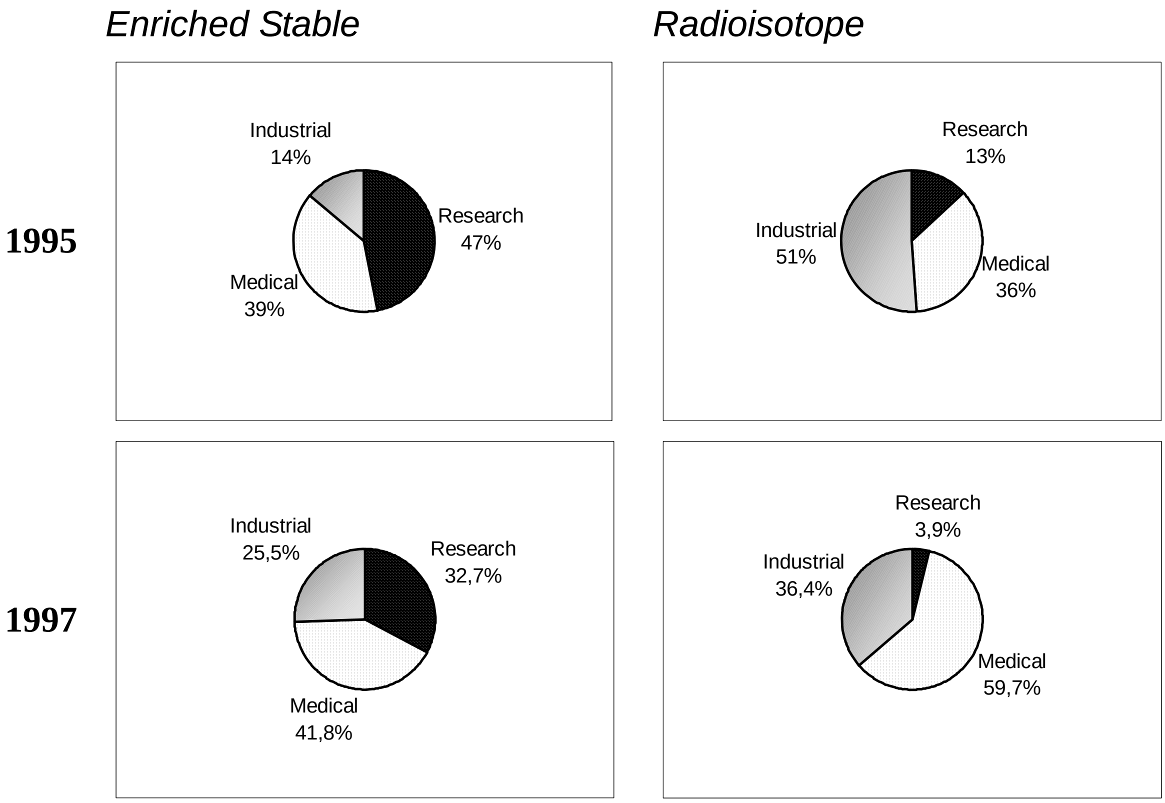

Figure 1. Applications of DOE Supplied Isotopes [1], [3]

It is necessary to mention, that this curtailment is not relative, but absolute. The total amount of sold isotope production (both stable, and radioactive) decreased from 15 millions dollars in 1995 [1] up to 11 millions dollars approximately in 1997 [3]. Thus, in the USA volume of researches with application of stable isotopes was reduced twice and with the application of radioisotopes – almost five times during two years.

It should be mentioned that the beginning of this recession (the first for many years) coincides with the beginning of a rapid progress both computer equipment and computer technologies of a different data's processing.

The tendency to decrease the use of ionising radiation sources and entailed by it the changes of stable isotopes consumption structure existing now (owing to cutting down necessity in stable isotopes used as start materials) can create serious problems for the producers of stable isotopes because these isotopes make the main part of their incomes. A small-scale production of the remaining isotopes, for example, applied in scientific researches, is unprofitable for the majority of the producers.

Thus, the beginning of the 21^{st} century can become the end of a traditional stable isotope production. It is possible to guess, that in the nearest future the main part of an output isotope production will be constituted by the small list of stable isotopes which are produced by large lots – such as depleted zinc for nuclear power, isotope-pure silicon for microelectronics, some isotopes of cadmium for laser systems engineering and some others, production quota of which has been increasing confidently last years.

[1] http://www.ornl.gov/isotopes/catalog.htm
[2] http://www.biot.com/cadwell/html
[3] http://www.ne.doe.gov/isotope/desc.html

A radiochemical detector for on-line monitoring of high-energy neutron fluxes

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A new method for monitoring cascade neutron fluxes inside an active zone of intense neutron sources is presented. The method is based on measurement of the decay rate of radioactive gases formed in nuclear reactions of neutrons with the nuclei of the detector substance. The proposed working substances of the detector are powder compounds of calcium and manganese possessing high radiation stability and melting points. The radioactive gas formed as the result of nuclear reactions ($^{40}Ca(n,\alpha)^{37}Ar$, for calcium compounds, or $^{26}Mg(n,\alpha)^{23}Ne$ for magnesium compounds freely diffuses from the powder substance of the detector. A carrier gas then transports the gas formed gas to an ionisation chamber of the decay counter situated outside an active zone.

This method has been earlier used for detecting solar neutrinos and has shown high efficiency for the on-line measurement of cascade neutron fluxes in an irradiation channel of the RADEX installation, forming a proton beam stop in an experimental hall of the linear proton accelerator of the Moscow Meson Factory INR RAS. The high efficiency of neutron registration allows the creation of compact radiochemical detectors, for constant use in the RADEX installation for mapping of neutron fluxes along the volume of the irradiation channel, without interfering with other experimental programs.