Summary of the research programme related to radionuclide metrology for the years 2004 and 2005 at the "Institut für Isotopenforschung und Kernphysik" (IIK) of the University of Vienna, Austria

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http://www.univie.ac.at/Kernphysik/irk_engl.htm

Presently, the activities at the IIK concentrate on the improvement and development of atomic and nuclear measuring techniques and data handling procedures for interdisciplinary applied physics work with special emphasis on the detection of long-lived radionuclides, particularly in the very-low-level range. Nuclear-decay-counting techniques have been widely replaced by mass-spectrometric techniques with high selectivity and high sensitivity. More detailed information about research at the IIK is also be provided via the institute's internet home page given above.

Due to a reorganization of the university structure and funding policies, that part of the institute which dealt with conventional radionuclide metrology had to leave the historical building of the old "Vienna Radium Institute" and move into a building close to the VERA facility (see below) with the new address given above. Preparations for the move started already in 2004, the transfer of the heavily shielded equipment and of radioactive sources (including a ^{241}Am-Be neutron source) still has to be postponed until working rooms have been adapted.

Names: M. Auer, O. Forstner , H. Friedmann, E. Friedl, R. Golser, J. Gröller, P. Hille, M. Kafesie, P. Kröpfl, J. Kühtreiber, W. Kutschera (director), J. Lukas, E. Pak, A. Pavlik, A. Priller, J. Riede, P. Steier, B. Strohmaier, S. Tagesen, H. Vonach, A. Wallner, F. Weninger, E. Wild, G. Winkler

1. The tandem-accelerator mass-spectrometry facility VERA (Vienna Environmental Research Accelerator) and its use

The VERA facility is based on a 3-MV Pelletron tandem accelerator (from National Electrostatics Corporation in Wisconsin, USA). For details on the experimental equipment see http://www.univie.ac.at/Kernphysik/VERA/welcome.htm .
Accelerator mass spectrometry (AMS) is a major field of research at the IIK. With AMS the radionuclides are measured by direct atom counting; selectivity is achieved employing energy-, momentum- and velocity-selecting devices (electrostatic, magnetic and time-of-flight/Wien filters) and using ion detectors for counting and final energy measurement. The interesting nuclides (with extremely small radioisotope-to-stable-isotope ratios in the 10^{-10} to 10^{-15} range) cannot be measured at natural levels through radioactive-decay counting, particularly for small samples in the milligram range, typically containing only 10^5 to 10^8 radionuclide atoms. Predominantly isotope ratios are measured relative to appropriate standards.

Typically, in the light-ion region atoms like ^{14}C (5.7×10^3 a, for radiocarbon dating), ^{10}Be ($T_{1/2}=1.5\times10^6$ a) and ^{26}Al ($T_{1/2}=7.2\times10^5$ a) (both for applications in geology) are counted with an excellent suppression of isobaric background. Through the recent upgrades of VERA it has been possible to measure also ions from very heavy long-lived radionuclides such as ^{129}I ($T_{1/2} \approx 1.6\times10^7$ a) [^{129}I/^{127}I ratios], ^{210}Pb ($T_{1/2} \approx 22$ a), ^{236}U ($T_{1/2} \approx 23\times10^6$ a) [marker for contamination by irradiated uranium, also daughter product of the decay of ^{240}Pu], ^{244}Pu ($T_{1/2} \approx 81\times10^6$ a) [for research on e.g. interstellar medium grains], ^{242}Pu ($T_{1/2} \approx 3.8\times10^5$ a) and ^{182}Hf ($T_{1/2} \approx$ $(9\pm2)\times10^6$ a) in natural samples.

2. Conventional radionuclide instrumentation and evaluation

a) Work using equipment as mentioned under item 3 of the last year's report has been hampered by the necessary move of all the devoted equipment to the new site of the institute (see above).

b) The conventional *^{14}C laboratory* was shut down, since a transfer to the new site was not possible.

3. Other projects

a) *Program to evaluate and check the reliability of the half-life values of some long-lived radionuclides("How well do we know our clocks")*
relevant to archaeochronology, geochronology and cosmochronology
[compare, e.g., F. Begemann et al., Call for an improved set of decay constants for geochronological use, Geochim. Cosmochim. Acta 65 (2001) 111-121].
In addition, the basic question of the change of half-lives due to stellar environments or other extreme environmental conditions are to be discussed.

Based on new attempts to extend the calibration for radiocarbon dating to periods more than 10 000 years ago, from the trend of the found calibration curve it may be suspected that the adopted value of the half-life of ^{14}C may has to be revised, or there may exist other reasons not yet known to explain the observed trend. Anyway, studies are undertaken to find a method for a direct accurate re-measurement of the half-life of ^{14}C.

b) *A critical review of experimental data for the half-lives of the uranium isotopes ^{238}U and ^{235}U* was published:
R. Schön, G. Winkler, W. Kutschera: Applied Radiation and Isotopes 60 (2004) 263 –273 (Proceedings of the 14th International Conference on Radionuclide Metrology and its Applications, ICRM 2003, in Dublin)

c) *Austrian National Radon Project (ÖNRAP)* [H. Friedmann]:
This project (see the previous years' reports) to determine the radon exposure of the population in Austria as well as to classify areas according to their potential radon risk from the ground ("radon potential"), is essentially completed (http://www.univie.ac.at/Kernphysik/oenrap/onrap_e.htm).
A "Radon information CD" (H. Friedmann) is also available.
Correlations between the so-called radon potential and details of the geology are to be investigated.

d) *Monte-Carlo simulation* of the of the *total detection efficieny of NaI(Tl) well-type detectors*, also for nuclides with complex decay schemes, is studied within a physics-diploma thesis, presently primarily using the PENELOPE code.

4. Work and co-operation on special reports and standard concepts, training tasks

Co-operation with the *Austrian Standards Institute* (OENORM) [H. Friedmann, G. Winkler] to achieve a uniform interpretation of low-level measurements and to harmonise measurement-uncertainty statements is continued.

Participation and lecturing in the *VERMI (Virtual European Radionuclide Metrology Institute) Young Researchers Workshop* (mainly on absolute counting methods) [1 – 5 Dec. 2003 at the CEA Headquarters, Paris, hosted by BNM-LNHB]; contributions by G. Winkler on "High-efficiency photon detection systems for accurate radioactivity measurements" and "The 4π-γ NaI(Tl) detector of the IIK, University of Vienna" on a VERMI CD issued in February 2004.

Students' training in the field of general experimental physics, quantum physics, atomic physics, nuclear physics, ion physics and radioactivity measurements is taken care of by the staff of the IIK.

5. Participation in international organisations

- International Committee for Radionuclide Metrology (ICRM) [G. Winkler];
- Consultative Committee for Ionising Radiation (CCRI), Section II (Measurement of Radionuclides) at the BIPM, Sèvres, France [personal member: G. Winkler];

April 2005 Gerhard Winkler