Summary of the research program related to radionuclide metrology for the years 2006 and 2007

at the "Institut für Isotopenforschung und Kernphysik" (IIK) (name until 31.Dec.2006), Working Groups "Isotopenforschung" (Isotope Research) and "Kernphysik" (Nuclear Physics) of the Faculty of Physics (since 1.Jan.2007)
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http://www.univie.ac.at/Kernphysik/irk_engl.htm

Some activities of the two research groups concentrate on the improvement and development of atomic and nuclear measuring techniques and data handling procedures for basic physics and 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 provided via the institute's internet home page given above. A reorganisation of the whole Faculty of Physics into the direction of a kind of department structure has been very recently introduced at the University of Vienna.

Names (including diploma and doctorate students): M. Auer, F. Dellinger, R. Drosg, O. Forstner , E. Friedl, H. Friedmann, R. Golser, J. Gröller, P. Hille, B. Jettmar, K. Knie, P. Kröpfl, J. Kühtreiber, W. Kutschera, St. Lehr, J. Lukas, K. Melber. L. Michlmayr, T. Orlowski, E. Pak, A. Pavlik, A. Priller, F. Quinto, K. Rumpelmayr, P. Steier, B. Strohmaier, S. Tagesen, H. Vonach, A. Wallner, F. Weninger, E. Wild, G. Winkler, B. Wünschek

Facilities, projects, tasks:

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

   For details on the experimental equipment see: http://www.univie.ac.at/Kernphysik/VERA/welcome.htm .
   Accelerator mass spectrometry (AMS) is a major tool for research. With AMS the radionuclides are measured by direct atom counting; selectivity is achieved employing energy-, momentum- and velocity-selecting devices (electrostatic, magnetic, velocity and time-of-flight 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, e.g., for applications in geology), heavy long-lived radionuclides such as ^{129}I ($T_{1/2}\approx 1.6\times10^7$ a), ^{236}U ($T_{1/2}\approx 23\times10^6$ a), ^{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) [of interest in astrophysics and geophysics] are counted in natural samples with an excellent suppression of isobaric background. Recently, AMS studies with ^{41}Ca and ^{55}Fe atoms were performed.

Projects involving radiocarbon measurements are, e.g.,

- "dating" of recent events using the "bomb peak"(^{14}C produced by nuclear weapons tests in the atmosphere prior to the Nuclear Test Ban Treaty in 1963), applied to problems of biophysics and biomedicine, antiquity and forensic science
- identification of carbonaceous aerosols
- synchronization of civilizations in the East Mediterranean: CHRONOLOGY FOR THE AEGEAN LATE BRONZE AGE 1700-1400 B.C.: S. W. Manning, C. Bronk Ramsey, W. Kutschera, T. Higham, B. Kromer, P. Steier, E. M. Wild; Science **312** (2006) 565-569

Some other recent publications relevant to radionuclide metrology are:

DETERMINATION OF PLUTONIUM IN ENVIRONMENTAL SAMPLES BY AMS AND ALPHA SPECTROMETRY,
E. Hrnecek, P. Steier, A. Wallner;
Applied Radiation and Isotopes 63 (2005) 633 - 638

HIGH PRECISION MEASUREMENTS OF ^{26}Na β^- DECAY,
G.F. Grinyer, et al.;
Physical Review C 71 (2005) 44309-1 – 44309-13

2. Conventional radionuclide measurements and evaluation

a) A further improved value of the *half-life of ^{44}Ti* was obtained from a 14-years long decay measurement relative to the half-life of ^{60}Co (assumed to be 5.2711 ± 0.0004 a), *that is 58.9 ± 0.3 years.*
I. Ahmad, J.P. Greene, E.F. Moore, S.Ghelberg, A. Ofan, M. Paul, W. Kutschera; to be published in Physical Review C (2007)

b) *The half-life of ^{183}Hf* was re-measured with high precision after it had been produced by the (n, γ) reaction on the long-lived *^{182}Hf [half-life (8.90 ± 0.09) × 10^6 a*; see the last year's report] giving a value *1.018 ± 0.002 hours.*
HALF-LIFE OF ^{183}Hf, C. Vockenhuber, M. Bichler, W. Kutschera, A. Wallner, I. Dillmann, F. Käppeler; Phys. Rev. C 74 (2006) 057303-1 to 057303-3

c) As a follow-up program of the *Austrian National Radon Project (ÖNRAP)* (http://www.univie.ac.at/Kernphysik/oenrap/onrap_e.htm) [H. Friedmann] correlations between the so-called radon potential and details of the geology are to be investigated; see
H. Friedmann: Final results of the Austrian Radon Project. Health Phys. **89(4)** (Oct. 2005) 339-348;
H. Friedmann: Radon Surveys and Uncertainties. Proceedings of the Second European IRPA Congress on Radiation Protection, Paris, 15-19 May 2006;
G. Dubois, P. Bossew, H. Friedmann: A geostatistical autopsy of the Austrian indoor radon survey (1992–2002). Science of the Total Environement. **377** (2007), p. 368-395.

d) Studies to assign uncertainties to the *Monte-Carlo simulation* of the *total detection efficieny of NaI(Tl) well-type detectors*, including the effect of electrons emitted from the source, will continue.

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

Co-operation with the *Austrian Standards Institute* (OENORM) [related to low-level measurements and harmonisation of uncertainty statements] is continued.

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.

4. Participation in international organisations dealing with radionuclide metrology

- 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]

May 2007 Gerhard Winkler