From Radium to Antihydrogen – A brief history of the Institute for Radium Research

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Meeting of the Alumni Club of the Japan Society for the Promotion of Science (JSPS)
Stefan Meyer Institute for Subatomic Physics, Vienna, 12 February 2016
Monument for Carl Auer von Welsbach

Physics and Chemistry of the University of Vienna

Physics Institutes (1912)

Radium Institute (1910)

I. Chemistry Institute (1914)

II. Chemistry Institute (1915)
Antoine Henri Becquerel (1852-1908)

Discovery of the spontaneous radioactivity of Uranium (1896)

Marie Sklodowska-Curie (1867-1934)

Discovery of Polonium and Radium in Uranium ore (1898)

Pierre Curie (1859-1906)

Nobel Prize in Physics 1903
Radioactivity research from 1900 to 1910

Research was conducted mainly in Paris (Marie and Pierre Curie) and at McGill and Manchester University (Ernest Rutherford)

What happened in Vienna?
In 1904, the geologist Eduard Suess, then president of the Royal Academy of Sciences in Vienna, authorized the chemist, inventor and entrepreneur Auer von Welsbach to extract Radium from 10,000 kg of Uranium ore tailings from Joachimsthal in Bohemia (now Jachymov, Czech Republic) in a plant in Atzgersdorf near Vienna, where Auer von Welsbach normally produced gas incandescent light units.

By 1908, ~3 g Radium had been extracted
Already at that time the Academy gave 300 mg Ra ‘on loan’ to Ernest Rutherford
In 1908, Dr. Karl Kupelwieser, a lawyer, industrialists, and philanthropist, donated half a million Crowns (~5 million Euros) to the Royal Academy of Sciences to build an “Institute for Radium Research” in Vienna. He was simply worried that Austria would miss the opportunity to use its own treasure – the Uranium from Joachimsthal – to perform research with Radium.
In 1910, the Institute for Radium Research was inaugurated. Stefan Meyer became the first director (1910-1938).

Victor Hess was the first assistant at the Institute for Radium Research (1910-1920).
In 1911, Otto Hönigschmid, who was visiting from the University of Prague, produced very pure Radium standards, and eventually determined the most precise and accurate atomic weight of $^{226}\text{Ra}$.

In 1912, Viktor Hess undertook 7 balloon flights to study the ionisation of air in closed chambers at different altitudes. At 5300 m he noticed that the ionisation had significantly increased as compared to the level near ground. Hess concluded that the cause is radiation from ‘above‘.
The discovery of cosmic rays
The increase of the ionisation of air with altitude as measured in balloon flights of Hess and Kohlhörster

1936 Nobel Prize in Physics

Victor Franz Hess
“for his discovery of cosmic radiation“

and

Carl David Anderson
“for his discovery of the positron“
In 1911, in Manchester, Ernest Rutherford imposed an interesting task to the young Hungarian chemist George de Hevesy: "My boy, if you are worth your salt, you separate Radium D from all that nuisance lead." – which turned out to be an impossible task because unknowingly to them RaD is a radioactive isotope of lead ($^{210}\text{Pb}$).

In 1912, after admitting “complete failure“, Hevesy went to the Radium Institute in Vienna and joined Fritz Paneth, who had a similar experience. However, they got the great idea to use RaD to trace chemical reactions of lead, and in this way established the isotope tracer method, for which George de Hevesy received the 1943 Nobel Prize in Chemistry.
Fig. 19. ‘England under attack from Austria-Hungary’: Three friends posing against the absurdity of WWI! From left to right: Georg von Hevesy, Robert W. Lawson and Victor F. Hess at the Vienna Institute for Radium Research, in 1916.
[Figure from Peter M. Schuster, The Scientific Life of Victor F. Hess, Astropart. Phys. 53 (2014) 33]
Karl Przibram joined the Radium Institut in 1912, and stayed there all his life, with the exception of the years 1938-1945.

His main field was the study of Radiophotolumineszenz, that is the effect of radiation on minerals.
From 1923 to 1938, Marietta Blau worked at the Radium Institute and developed a method of detecting charged particles in photographic emulsions. In 1937, Blau and Warmbacher made the first observation of a nuclear disintegration (star) in photographic plates exposed 5 months to cosmic rays at the Victor-Hess Observatory on Hafelekhar near Innsbruck (2300 m a.s.l.).

Because Marietta Blau had to leave in 1938, she missed out on the discovery of the Pion by her method, which earned Cecil Powell the 1950 Nobel Prize in Physics.

1938-1945: Gustav Ortner, Director

1938: People who had to leave: Stefan Meyer, Karl Przibram, Marietta Blau, Elisabeth Rona

1940: W. Jentschke and F. Prankl measured the mass and energy distribution of fission products from Uranium after irradiation with thermal neutrons (published in 1942, Zeitschrift für Physik 119:696). After the war, Jentschke spent some time in the USA and then build up DESY in Hamburg, and was also Director General of CERN 1971-1976.

1941/42: J. Schintlmeister and F. Hernegger studied an unknown radioactive element with a radiation of ‘1.8-cm alpha particles’, which Schintlmeister thought may be a fissionable element. After the war, Schintlmeister spent 10 years in Russia, then went to TU Dresden, where he proved with modern alpha counting methods that the new element from the war time did not exist.

1944: B. Karlik and T. Bernert found evidence for the short-lived Astatine isotopes $^{215}$At, $^{216}$At, and $^{218}$At as minor branches in the natural decay series (Zeitschrift für Physik 1944, 123: 51).
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**From 1929 on,** Berta Karlik worked at the Radium Institute.

**From 1947 to 1974** she was the director of the institute.

**Berta Karlik**
(1904 – 1990)

**Traute Bernert and Berta Karlik**
Institute for Radium Research (after 1945)

1947-1974: Berta Karlik, Director

1956: renamed Institute for Radium Research and Nuclear Physics
Home-made T(d,n)$^4$He neutron generator, nuclear physics with 14-MeV neutrons
Development of $^{14}$C laboratory with beta counting method ($^{14}$CH$_4$)
Electronic and detector development

1974-1987: Herbert Vonach, Director

New T(d,n)$^4$He neutron generator on the roof of the building
Continuation of nuclear physics with 14-MeV neutrons
$^{14}$C Laboratory, applied nuclear physics
Muon catalyzed fusion studies at Paul Scherrer Institute (PSI), Switzerland

1987:

Austrian Academy of Sciences
Institute for Medium Energy Physics

University of Vienna
Institute for Radium Research & Nuclear Physics

1987-2002: Wolfgang Breunlich, Director
Muon catalyzed fusion studies at TRIUMF
Exotic atoms, pionic atoms, kaonic atoms

2002-2004: Paul Kienle, Director

1987-1992: Herbert Vonach, Director

1992-1994: Peter Hille, Director

1994-1996: Walter Kutschera, built-up of the Vienna Environmental Research Accelerator (VERA) at Währingerstr. 17
2004: Re-use of the historic building of the Institute for Radium Research

- The Institute for Radium Research and Nuclear Physics (in 2002 renamed Institute for Isotope Research and Nuclear Physics) of the University of Vienna moved to VERA in Währingerstrasse 17.

- The new Institute of Quantum Optics and Quantum Information (IQOQI) of the Austrian Academy of Sciences was established in the upper part of the building.

- The Institute of Medium Energy Physics (IMEP) of the Austrian Academy of Sciences was renamed Stefan Meyer Institute of Subatomic Physics (SMI).
The ‘Kavalierstrakt‘, Währingerstrasse 17, 1090 Vienna


Now the home of the Vienna Environmental Research Accelerator (VERA) and the Institute for Isotope Research and Nuclear Physics of the University of Vienna
VERA
Vienna Environmental Research Accelerator

walls removed

entrance for accelerator
Accelerator Mass Spectrometry (AMS) for “all” isotopes: $^{10}$Be, $^{14}$C, $^{26}$Al, $^{36}$Cl, $^{41}$Ca, $^{55}$Fe, $^{129}$I, $^{182}$Hf, $^{210}$Pb, $^{210}$Bi, $^{236}$U, $^{239-244}$Pu, SHE, (H$_2$)$^-$, ($^{43}$Ca$^{19}$F$_4$)$^-$, PIXE-ART, Nucl. reactions: 6,7Li.
Staff of VERA

**Robin Golser**
Head of Isotope Research Group

*Research interests*
Atomic physics (exotic ions), ion beam analysis (PIXE and PIGE), Laser AMS

**Eva Maria Wild**
Vice Head of Isotope Research Group, Head of $^{14}$C dating, sample preparation and stable isotope lab

*Research interests*
Archaeology ($^{14}$C), paleodiets ($\delta^{13}$C, $\delta^{15}$N), paleoclimate ($^{10}$Be, $^{26}$Al)

**Alfred Priller**
Technical Head of VERA

*Research interests*
Accelerator development (ion source, injector), loess and paleoclimate ($^{10}$Be)

**Peter Steier**
Head of VERA Operation

*Research interests*
Glacier dating ($^{14}$C), DNA dating ($^{14}$C), environmental physics ($^{36}$Cl, $^{236}$U, $^{244}$Pu)

**Johannes Lachner**
Postdoc

*Research interest*
Instrumentation, new AMS isotopes ($^{135}$Cs, $^{182}$Hf, …) Laser AMS, Laser interaction with negative ions

**Martin Martschini**
Postdoc

*Research interests*
Detector development, AMS of $^{10}$Be, $^{36}$Cl, … Laser AMS, Laser interaction with negative ions
Accelerator Mass Spectrometry (AMS) for "all" isotopes: $^{10}$Be, $^{14}$C, $^{26}$Al, $^{36}$Cl, $^{41}$Ca, $^{55}$Fe, $^{129}$I, $^{182}$Hf, $^{210}$Pb, $^{210}$Bi, $^{236}$U, $^{293-244}$Pu, SHE, $(H_2)^+$–, $(^{43}Ca_19F_4)^−$ – PIXE-ART, Nucl. reactions:

**Negative-Ion Sources**

- **Negative-Ion Mass Spectrometer (keV)**
  - Source
  - 75 kV Preacceleration
  - Insertable Faraday Cup
  - Electromagnetic Analyzer E/q=90 keV r=0.300 m
  - Beam-Switch
  - Magnetic Quadrupole Doublet
  - Multi Beam Switcher
  - x/y-Slits
  - Beam Profile Monitor

**Interaction of laser with negative ions (e-detachment)**

- Laser
- Power
- RF-Quadrupol

**Stripping and Molecule Dissociation**

- +3 MV Tandem Accelerator
- Wienfilter $E_x B = 35 \text{ kV/cm} \times 0.4 \text{ T}$
- Analyzing Magnet $ME/q^2=176 \text{ MeV amu}$
  - $r=1.270 \text{ m}$

**Positive-Ion Mass Spectrometer (MeV)**

- $^{236}$U/$^{238}$U
  - $\sim 10^{-16}$

**VERA Environmental Research Accelerator**

- 1996: 1st operation
- 2001: 1st upgrade
- 2007: 2nd upgrade
- 2013: 3rd upgrade
- 2016: 4th upgrade

**Negative Ion Source**

- 236U/238U
- $\sim 10^{-16}$

**Electrostatic Analyzer**

- $E/q=4.4 \text{ MeV}$
  - $r=2.000 \text{ m}$
Probing Strong Interaction with Kaonic Hydrogen and Helium Atoms
(Frascati, Italy; KEK, Japan)

Probing Strong Interaction with Kaonic Deuterium Atoms
(J-PARC, Japan)

Search for Deeply Bound Kaonic Nuclei
(KEK, Japan; FOPI, GSI, Germany; J-Park, Japan)

Spectroscopy of Antiprotonic Helium and Antihydrogen
and Gravitation of Antihydrogen
(Antiproton Decelerator of CERN)

Future PANDA experiment to study antiproton-proton interaction
(FAIR, Germany)
Hyperfine Structure of Antihydrogen (ERC Grant of Eberhard Widmann)
28 May 2015: Inauguration of the Institute for Radium Research as a Historic Site of the European Physical Society (EPS)

People from left to right: Peter M. Schuster (Chair of History of Physics Group, EPS), Eberhard Widmann (Director of SMI), Margit Fischer (First Lady of Austria), Luisa Cifarelli (Chair of EPS Historic Site Committee and past President of EPS), Anton Zeilinger (President of Austrian Accademy of Sciences), Caslav Brukner (Director of IQOQI)
**HISTORIC SITE**
**EUROPEAN PHYSICAL SOCIETY (EPS)**
**INSTITUTE FOR RADION RESEARCH**

In 1910, in this building, the "Institute for Radium Research" of the Imperial Academy of Sciences was established and inaugurated as the first of its kind worldwide. Under Stefan Meyer, the new institute dedicated extensive research into the physical properties of the radioactive element radium.

The major contributions of Victor Franz Hess, the discoverer of cosmic radiation, George de Hevesy and Friedrich Paneth, inventors of the use of isotopic tracers in the study of chemical processes, as well as those of Marietta Blau, pioneer in nuclear-emulsion detectors, and of Karl Przibram, leader in radiation-induced luminescence and colour change of glass and minerals, were achieved here.

**HISTORISCHE STÄTTE**
**EUROPÄISCHE PHYSikalische GESELLSCHAFT (EPS)**
**INSTITUT FÜR RADIUMFORSCHUNG**


*WIEN – 28. MAI 2015*