EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Status Report to the ISOLDE and Neutron Time-of-Flight Committee

(29 April 2009)

Scientific highlights and future plans at the ISOLTRAP setup

By the ISOLTRAP Collaboration:

G .Audi [1], D. Beck [2], K. Blaum [3], Ch. Böhm [3], Ch. Borgmann [3], M. Breitenfeldt [4], D. Fink [3], S. George [3], F. Herfurth [2], A. Herlert [5], A. Kellerbauer [3], H-J. Kluge [2], M. Kowalska [5], D. Lunney [1], E. Minaya-Ramirez [1], S. Naimi [1], D. Neidherr [3], M. Rosenbusch [4], S. Schwarz [6], L. Schweikhard [4], U. Warring [3], R. Wolf [4], K. Zuber [7]

1 CSNSM-IN2P3-CNRS, Université de Paris Sud, 91406 Orsay, France
2 GSI, Planckstraße 1, 64291 Darmstadt, Germany
3 MPI für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany
4 Institut für Physik, Ernst-Moritz-Arndt-Universität, 17487 Greifswald, Germany
5
6 NSCL, Michigan State University, East Lansing, Michigan 48824-1321, USA
7 Institut für Kern- und Teilchenphysik, Technische Universität, 01069 Dresden, Germany

CERN-INTC-2009-027 / INTC-SR-013
29/04/2009

Recent highlights at the Penning trap mass spectrometer ISOLTRAP [1] concern high-precision masses of nuclei in several regions of the nuclear chart. They are relevant for the unitarity of the Cabibbo-Kobayashi-Maskawa (CKM) quark-mixing matrix, critical aspects of nucleosynthesis, magic numbers and the proton-neutron interaction, or the light nuclei exhibiting halo and clustering phenomena.

Physics highlights:

In the region of light nuclei, we have recently studied the masses of neutron-deficient neon isotopes, including the **two-proton-halo candidate ^{17}Ne** [2]. The data were also used to derive precise charge radii from the laser-spectroscopy studies at the COLLAPS setup. Both the binding energies and the radii are very well described by theory (Fermionic Molecular Dynamics model) which reveals a wealth of phenomena in the studied region. Additionally to the possible two-proton halo structure of ^{17}Ne, a closed neutron shell is visible for ^{18}Ne, whereas ^{19}Ne and ^{20}Ne exhibit a cluster structure [2].

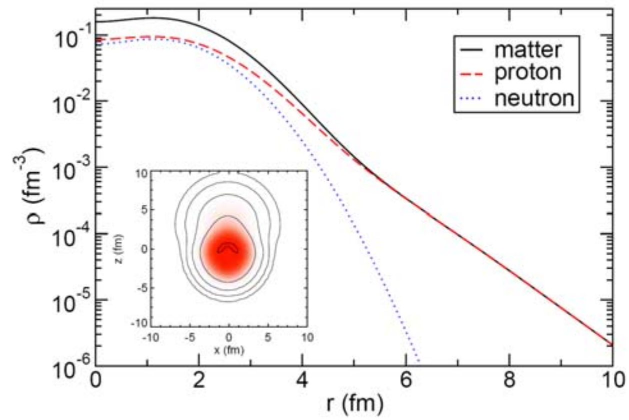

Fig. 1. Matter, proton and neutron density distributions in the FMD ground state for ^{17}Ne. The probability to find a proton at r >5 fm is about 40%. Insert: intrinsic proton density of the dominant FMD configuration, with two protons in s-d mixed orbits.

Close to the N=Z line we have determined the masses of ^{26}Al and ^{38}Ca relevant for the weak interaction studies. The results gave us a comparative half-life (**Ft value**) for the **superallowed** β decay of **^{26m}Al** [3] and **^{38}Ca** [4] to further test the conserved vector-current (CKM) hypothesis and ultimately to better determine the V_{ud} element of the Cabibbo-Kobayashi-Maskawa (CKM) quark-mixing matrix. Both values are now included in the latest compilation of the superallowed 0^+ -> 0^+ nuclear decays [5], which shows that the unitarity of the CKM matrix is fully satisfied at the 0.06% level.

We have furthermore investigated the **neutron-rich ^{80,81}Zn** [6] **and ^{132,134}Sn** [7], which are important for the N=50 and 82 shell closures, as well as for the nucleosynthesis rapid neutron capture (r process). The derived two-neutron separation energies show that both N=50 and 82 retain their magicity for these neutron-rich nuclides. The obtained neutron-capture Q-values allow mapping precisely the astrophysical conditions required for the ^{80}Zn and ^{132}Sn waiting points and their associated abundance signatures to occur in r-process models. In addition, ^{80}Zn is the first of the few major waiting points along the path of the astrophysical rapid neutron-capture process where neutron-separation energy and neutron-capture Q-value are determined experimentally.

The most recent ISOLTRAP achievement is the first-time determination of the **masses of 7 radon isotopes, $^{223\text{-}229}$Rn** [8]. These can be used to investigate the residual proton-neutron (p-n) interaction far from stability, since the average interaction of the last proton(s) and neutrons(s) can be obtained from double mass differences (the so called δV_{pn} values) [9]. Based on the new Rn masses a unique parabola behaviour was revealed in the δV_{pn} values for the Ra chain, with a peak for ^{223}Ra, which might be connected to the octupole deformation known to exist in this region of the nuclear chart. In addition, a new nuclide, **^{229}Rn**, was **identified for the first time in a Penning trap** [8], the production of which was enhanced by the use of a new, highly-efficient arc-discharge ion source [10]. Its half-life was later determined by beta-spectroscopy to be 12 s.

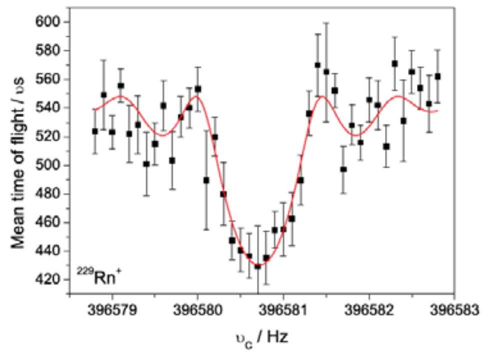

Fig. 2. Time-of-Flight ion-cyclotron-resonance of ^{229}Rn, a nuclide observed for the first time ever. The solid line is a fit of the expected line shape to the data points.

In total in the period 2006-2009 ISOLTRAP used 50 online shifts within 5 approved proposals (IS413, IS437, IS461, IS463, IS473). This resulted in 65 measured masses (Fig. 3), 13 of which were determined for the first time. In addition, one new nuclide was identified. The results have been published in 29 scientific peer-reviewed papers, among them 6 Physical Review Letters, and entered a large number of PhD and diploma theses (see list of references).

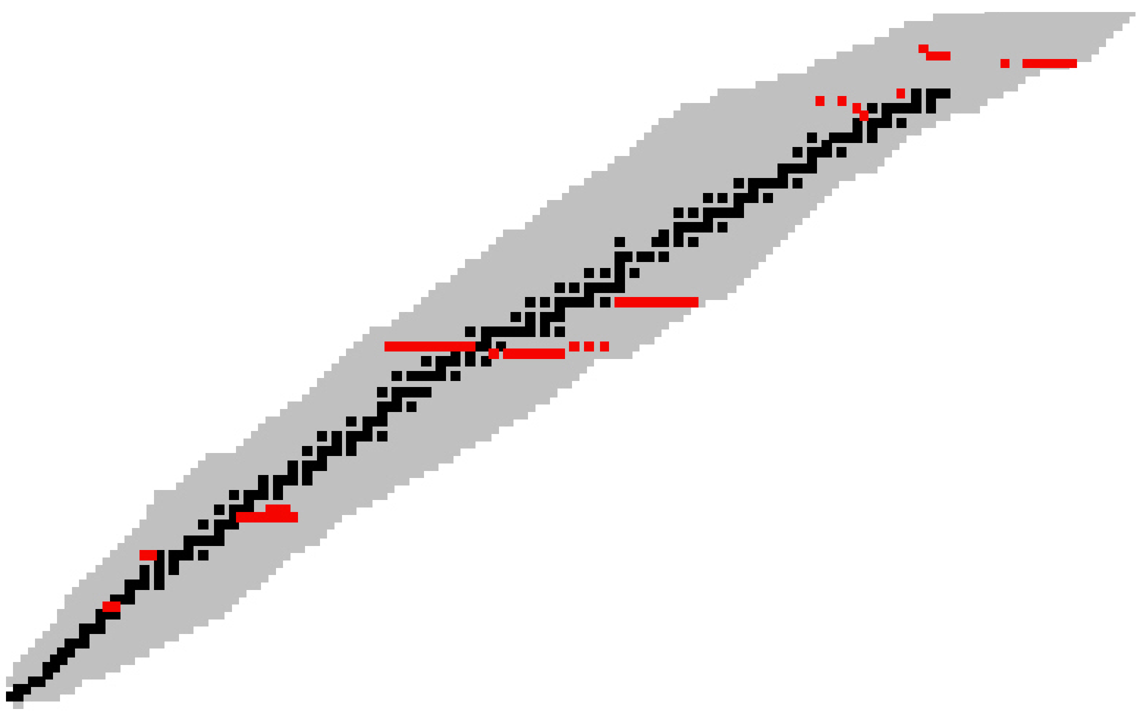

Fig. 3. The atomic masses measured at ISOLTRAP (red) in years 2006-2009.

Technical developments:

Recently, a new excitation scheme for determining the ion cyclotron frequency, and from it the atomic mass, was used at ISOLTRAP [11]. It is based on separated oscillatory fields (the **Ramsey method**) and it has been applied successfully both in offline and online conditions. The online mass measurements on ^{26}Al [3] and ^{38}Ca [4] gave a statistical uncertainty similar to that obtained by the conventional technique but 10 times faster. The method offers also the possibility to achieve a higher precision (more than a factor of three) with the same observation time as with the conventional method using one rf pulse. This breakthrough in precision Penning trap mass spectrometry has meanwhile been applied at all other Penning trap facilities for radionuclides in the world.

Thanks to the use of the **in-trap-decay technique** [12] we could measure for the first time nuclides not accessible at ISOLDE directly. The studied iron isotopes, $^{61\text{-}63}$Fe [12], were created in the preparation Penning trap from the decay of the stored manganese mother ions, delivered to ISOLTRAP from the ISOLDE target. The method has been recently tested at the REX-TRAP system and opens the possibility to study more elements which are otherwise not accessible directly at ISOLDE.

We have also pursued a project to use the traps as isobaric and isomeric **purifiers for decay studies** on beams whose studies are hampered due to contamination. In 2008 we installed behind the precision trap a β- and γ-detection chamber coupled to a tape system which can take away the daughter radioactivity [13]. We also performed the first tests with a radioactive beam as part of the preparations for studies of the neutron-rich thallium and mercury isotopes which suffer from francium contamination [13].

Future plans:

The measurements planned for 2009 and 2010 include the masses of short-lived Kr and Ar isotopes, using the new highly-efficient plasma ion source [5]. Among these, the mass of ^{48}Ar is important for the possible disappearance of *N*=28 shell closure for neutron-rich nuclei, $^{96\text{-}98}$Kr masses beyond the *N*=58 sub-shell closure will allow to refine the r process path predictions, and the mass of ^{70}Kr will contribute to modeling the complementary rapid proton capture (rp process). We also plan to investigate the neutron-rich ^{82}Zn and Ag isotopes important for the r-process and its waiting-point nuclides. In the offline periods we want to measure the *Q*-values of very long-lived candidates for the neutrino-less double-beta decay.

On the technical side, we plan to perform further tests to fully commission the tape station for decay spectroscopy. In the upcoming shutdown period we also will install behind our cooler/buncher an electrostatic trap aimed at purifying the beam, which will assist the preparation Penning trap in beam purification, since it handle higher beam intensities. For the offline studies of long-lived species, we plan to modify the present laser ion source to allow not only carbon-cluster, but also metal ionisation. In the mid-term future, within the HIE-ISOLDE project, we will investigate possibilities of handling highly-charged ions at ISOLTRAP [14]. This will allow shortening the measurement cycle while preserving the achievable precision or increasing the precision while keeping the excitation time the same as for singly-charged ions.

[1] M. Mukherjee *et al*., Eur. Phys. J. A 35, 1 (2008)
[2] W. Geithner *et al*., Phys. Rev. Lett. 101, 252502 (2008)
[3] S. George *et al*., Europhys. Lett. 82, 50005 (2008)
[4] S. George *et al*., Phys. Rev. Lett. 98, 162501 (2007)
[5] J.C. Hardy, I.S. Towner, arXiv:0812.1202 (2008)
[6] S. Baruah *et al*., Phys. Rev. Lett. 101, 262501 (2008)
[7] M. Dworschak *et al*., Phys. Rev. Lett. 100, 072501 (2008)
[8] D. Neidherr *et al*., Phys. Rev. Lett. 102, 112501 (2009)
[9] B. Cakirli *et al*., Phys. Rev. Lett. 102, 082501 (2009)
[10] L. Penescu *et al*., Nucl. Instrum. Methods B 266, 4415 (2008)
[11] S. George *et al*., Int. J. Mass Spectrom. 264, 110-121 (2007)
[12] A. Herlert *et al*., New J. Phys. 7 44 (2005)
[13] M. Kowalska *et al*., submitted to Eur. Phys. J. A (2009)
[14] HIE-ISOLDE: the technical options, CERN-2006-013

Some statistics on the reporting period: 2004-2009

Number of taken radioactive beam shifts:

2004: 19
2005: 30
2006: 10.5
2007: 22.5
2008: 17

total: 99

Number of publications: 55 (1 per 2 shifts)
Number of Phys. Rev. Lett.: 10 (1 per 10 shifts)

Number of PhD theses: 8 completed, 5 in progress
Number of diploma theses: 6 completed, 1 in progress

List of Publications 2004-2009

IS413, IS461, IS473

2009:

56. **Investigation of space-charge phenomena in gas-filled Penning traps.**
S. Sturm, K. Blaum, M. Breitenfeld, P. Delahaye, A. Herlert, L. Schweikhard, F. Wenander.
In: "Non-neutral plasma physics PHYSICS VII: Workshop on Non-Neutral Plasmas 2008" (New York (NY) USA, 16-20 June 2008), J.R. Danielson, T.S. Pedersen (Eds.), AIP Conf. Proc. 1114, 185-190 (2009).

55. **Discovery of ^{229}Rn and the structure of the heaviest Rn and Ra isotopes from Penning trap mass measurements.**
D. Neidherr, G. Audi, D. Beck, K. Blaum, Ch. Böhm, M. Breitenfeldt, R.B. Cakirli, R.F. Casten, S. George, F. Herfurth, A. Herlert, A. Kellerbauer, M. Kowalska, D. Lunney, E. Minaya-Ramirez, S. Naimi, E. Noah, L. Penescu, M. Rosenbusch, S. Schwarz, L. Schweikhard, T. Stora.
Phys. Rev. Lett. 102, 112501 1-5 (2009).

54. **An enhanced sensitivity of nuclear energies to collective structure.**
R.B. Cakirli, R.F. Casten, R. Winkler, K. Blaum, M. Kowalska.
Phys. Rev. Lett. 102, 082501 1-4 (2009).

53. **Electric and magnetic field optimization procedure for Penning trap mass spectrometers.**
D. Beck, K. Blaum, G. Bollen, P. Delahaye, S. George, C. Guénaut, F. Herfurth, A. Herlert, D. Lunney, L. Schweikhard, C. Yazidjian.
Nucl. Instrum. Meth. A, 598, 635 – 641 (2009) arXiv:0805.4549v1 [physics.ins-det].

2008:

52. **Mass measurements beyond the major *r*-process waiting point ^{80}Zn.**
S. Baruah, G. Audi, K. Blaum, M. Dworschak, S. George, C. Guénaut, U. Hager, F. Herfurth, A. Herlert, A. Kellerbauer, H.-J. Kluge, D. Lunney, H. Schatz, L. Schweikhard, C. Yazidjian.
Phys. Rev. Lett., 101, 262501 1 – 4 (2008).

51. **Masses and charge radii of $^{17-22}$Ne and the two-photon-halo candidate ^{17}Ne.**
W. Geithner, T. Neff, G. Audi, K. Blaum, P. Delahaye, H. Feldmeier, S. George, C. Guénaut, F. Herfurth, A. Herlert, S. Kappertz, M. Keim, A. Kellerbauer, H.-J. Kluge, M. Kowalska, P. Lievens, D. Lunney, K. Marinova, R. Neugart, L. Schweikhard, S. Wilbert, C. Yazidjian.
Phys. Rev. Lett. 101, 252502, 1 – 4 (2008).

50. **Nuclear masses in astrophysics.**
C. Weber, K. Blaum, H. Schatz.
10th Symposium on Nuclei in the Cosmos, 27 July – 1 Aug. 2008, Mackinac Island, Michigan, USA.
Proceedings of Science, PoS (NIC X), 028, arXiv0812.1675 (2008).

49. **The elliptical Penning trap: Experimental investigations and simulations.**
M. Breitenfeldt, S. Baruah, K. Blaum, A. Herlert, M. Kretzschmar, F. Martinez, G. Marx, L. Schweikhard, N. Walsh.
Int. J. Mass Spectrom. 275, 34-44 (2008).

48. **Trapped Charged Particles and Fundamental Interactions.**
Series: Lecture Notes in Physics , Vol. 749
Blaum, Klaus; Herfurth, Frank (Eds.)
2008, X, 200 p.
ISBN: 978-3-540-77816-5.

47. **Time-separated oscillatory fields for high-precision mass measurements on short-lived Al und Ca nuclides.**
S. George, G. Audi, B. Blank, K. Blaum, M. Breitenfeldt, U. Hager, F. Herfurth, A. Herlert, A. Kellerbauer, H.-J. Kluge, M. Kretzschmar, D. Lunney, R. Savreux, S. Schwarz, L. Schweikhard, C. Yazidjian.
Europhys. Lett. 82, 50005/p.1-6 (2008), arXiv e-print: 0801.2593v1 [nucl-ex].

46. **Atomic mass measurements of short-lived nuclides around the doubly-magic ^{208}Pb.**
C. Weber, G. Audi, D. Beck, K. Blaum, G. Bollen, F. Herfurth, A. Kellerbauer, H.-J. Kluge, D. Lunney, S. Schwarz.
Nucl. Phys. A 803, 1-29 (2008), arXiv:0801.2068v1 [nucl-ex].

45. **Towards a magnetic field stabilization at ISOLTRAP for high-accuracy mass measurements on exotic nuclides.**
M. Marie-Jeanne, J. Alonso, K. Blaum, S. Djekic, M. Dworschak, U. Hager, A. Herlert, Sz. Nagy, R. Savreaux, L. Schweikhard, S. Stahl, C. Yazidjian.
Nucl. Instrum. Meth. A 587, 464-473, arXiv e-print: physics/0701224 (2008).

44. **Mass measurements and evaluation around *A*=22.**
M. Mukherjee, D. Beck, K. Blaum, G. Bollen, P. Delahaye, J. Dilling, S. George, C. Guénaut, F. Herfurth, A. Herlert, A. Kellerbauer, H.-J. Kluge, U. Köster, D. Lunney, S. Schwarz, L. Schweikhard, C. Yazidjian.
Eur. Phys. J. A 35, 31-37 (2008).

43. **ISOLTRAP: An on-line Penning trap for mass spectrometry on short-lived nuclides.**
M. Mukherjee, D. Beck, K. Blaum, G. Bollen, J. Dilling, S. George, F. Herfurth, A. Herlert, A. Kellerbauer, H.-J. Kluge, S. Schwarz, L. Schweikhard, C. Yazidjian.
Eur. Phys. J. A 35, 1-29 (2008).

42. **Restoration of the N = 82 Shell Gap from Direct Mass Measurements of ^{132,134}Sn.**
M. Dworschak, G. Audi, K. Blaum, P. Delahaye, S. George, U. Hager, F. Herfurth, A. Herlert, A. Kellerbauer, H.-J. Kluge, D. Lunney, L. Schweikhard, C. Yazidjian.
Phys. Rev. Lett. 100, 072501 (2008).

2007:

41. **High-precision masses of neutron-deficient rubidium isotopes using a Penning trap mass spectrometer.**
A. Kellerbauer, G. Audi, D. Beck, K. Blaum, G. Bollen, C. Guénaut, F. Herfurth, A. Herlert, H.-J. Kluge, D. Lunney, S. Schwarz, L. Schweikhard, C. Weber, C. Yazidjian.
Phys. Rev. C 76, 045504 (2007).

40. **Evidence for a breakdown of the isobaric multiplet mass equation: A study of the A = 35, T = 3/2 isospin quartet.**
C. Yazidjian, G. Audi, D. Beck, K. Blaum, S. George, C. Guénaut, F. Herfurth, A. Herlert, A. Kellerbauer, H.-J. Kluge, D. Lunney, L. Schweikhard.
Phys. Rev. C 76, 024308 (2007).

39. **The Ramsey method in high-precision mass spectrometry with Penning traps: Experimental results**

S. George, K. Blaum, F. Herfurth, A. Herlert, M. Kretzschmar, Sz. Nagy, S. Schwarz, L. Schweikhard, C. Yazidjian
Int. J. Mass Spectrom. 264, 110-121 (2007).

38. **Ramsey Method of Separated Oscillatory Fields for High-Precision Penning Trap Mass Spectrometry.**
S. George, S. Baruah, B. Blank, K. Blaum, M. Breitenfeldt, U. Hager, F. Herfurth, A. Herlert, A. Kellerbauer, H.-J. Kluge, M. Kretzschmar, D. Lunney, R. Savreux, S. Schwarz, L. Schweikhard, C. Yazidjian.
Phys. Rev. Lett. 98, 162501 (2007).

37. **High-precision mass measurements of nickel, copper, and gallium isotopes and the purported shell closure at *N*=40**
C. Guénaut, G. Audi, D. Beck, K. Blaum, G. Bollen, P. Delahaye, F. Herfurth, A. Kellerbauer, H.-J. Kluge, J. Libert, D. Lunney, S. Schwarz, L. Schweikhard, C. Yazidjian.
Phys. Rev. C 75, 044303 (2007).

2006:

36. **High-accuracy mass measurements of neutron-rich Kr isotopes.**
P. Delahaye, G. Audi, K. Blaum, F. Carrel, S. George, F. Herfurth, A. Herlert, A. Kellerbauer, H.-J. Kluge, D. Lunney, L. Schweikhard, C. Yazidjian.
Phys. Rev. C. 74, 034331 (2006).

35. **Towards high-accuracy mass spectrometry of highly charged short-lived ions at ISOLTRAP.**
A. Herlert, S. Baruah, K. Blaum, P. Delahaye, M. Dworschak, S. George, C. Guénaut, U. Hager, F. Herfurth, A. Kellerbauer, M. Marie-Jeanne, S. Schwarz, L. Schweikhard, C. Yazidjian.
Int. J. Mass Spectrom. 251, 131-137 (2006).

34. **Accurate mass measurements on neutron-deficient krypton isotopes.**
D. Rodríguez, G. Audi, J. Äystö, D. Beck, K. Blaum, G. Bollen, F. Herfurth, A. Jokinen, A. Kellerbauer, H.-J. Kluge, V.S. Kolhinen, M. Oinonen, E. Sauvan, and S. Schwarz.
Nucl. Phys. A 769, 1-15 (2006).

33. **High-accuracy mass spectrometry with stored ions.**
K. Blaum.
Phys. Rep. 425, 1-78 (2006).

32. **A new Channeltron-detector setup for precision mass measurements at ISOLTRAP.**
C. Yazidjian, K. Blaum, R. Ferrer, F. Herfurth, A. Herlert, L. Schweikhard.
International Conference on Trapped Charged Particles TCP 2006, Vancouver, Canada
Hyp. Int. 173, 181-193 (2006).

31. **Penning trap mass spectrometry for nuclear structure studies**
K. Blaum, D. Beck, M. Breitenfeldt, S. George, F. Herfurth, A. Herlert, A. Kellerbauer, H.-J. Kluge, D. Lunney, R. Savreux, S. Schwarz, L. Schweikhard, C. Yazidjian
LASER2006 Conference
Hyp. Int. 171, 83-91 (2006).

30. **Spin-related aspects of mass determination of radionuclides**
A. Herlert, S. Baruah, K. Blaum, P. Delahaye, M. Dworschak, S. George, C. Guénaut, U. Hager, F. Herfurth, A. Kellerbauer, H.-J. Kluge, S. Schwarz, L. Schweikhard, C. Weber, C. Yazidjian
International Conference on Spin related Aspects SpinPraha2006, Praha, Czech Republic 2006
Czech. J. Phys. 56, F277-F286 (2006).

29. **High-precision mass measurements for reliable nuclear astrophysics calculations**
A. Herlert, S. Baruah, K. Blaum, M. Breitenfeldt, P. Delahaye, M. Dworschak, S. George, C. Guénaut, U. Hager, F. Herfurth, A. Kellerbauer, H.-J. Kluge, R. Savreux, S. Schwarz, L. Schweikhard, C. Yazidjian
International Symposium on Nuclear Astrophysics – Nuclei in the Cosmos – IX, CERN, Geneva, Switzerland 2006
Proceedings of Science, PoS(NIC-IX) 051 (2006).

28. **High-precision mass measurements on neutron deficient neon isotopes**
A. Herlert, S. Baruah, K. Blaum, P. Delahaye, S. George, C. Guénaut, F. Herfurth, H.-J. Kluge, D. Lunney, S. Schwarz, L. Schweikhard, C. Weber, C. Yazidjian
FINUSTAR Conference, Kos, Greece 2005,
AIP Conference Proceedings 831, 152-156 (2006).

27. **ISOLTRAP Mass Measurements for Weak-Interaction Studies**
A. Kellerbauer, G. Audi, D. Beck, K. Blaum, G. Bollen, P. Delahaye, S. George, C. Guénaut, F. Herfurth, A. Herlert, H.-J. Kluge, D. Lunney, M. Mukherjee, D. Rodríguez, S. Schwarz, L. Schweikhard, C. Weber, C. Yazidjian
FINUSTAR Conference, Kos, Greece 2005,
AIP Conference Proceedings 831, 49-54 (2006).

2005:

26. **Mass measurements on neutron-deficient Sr and neutron-rich Sn isotopes with the ISOLTRAP mass spectrometer**
G. Sikler, G. Audi, D. Beck, K. Blaum, G. Bollen, F. Herfurth, A. Kellerbauer, H.-J. Kluge, D. Lunney, M. Oinonen, C. Scheidenberger, S. Schwarz, J. Szerypo, and C. Weber
Nucl. Phys. A 763, 45-58 (2005) and 768, 160 (2005).

25. **Atomic Clusters and Ion Cyclotron Resonance Mass Spectrometry – a Fruitful Combination**
L. Schweikhard, K. Blaum, A. Herlert, and G. Marx
Eur. J. Mass Spectrom. 11, 457-468 (2005).

24. **Weighing excited nuclear states with a Penning trap mass spectrometer**
C. Weber, G. Audi, D. Beck, K. Blaum, G. Bollen, F. Herfurth, A. Kellerbauer, H.-J. Kluge, D. Lunney, S. Schwarz
Phys. Lett. A 347, 81-87 (2005).

23. **Effects of the pairing energy on nuclear charge radii**
C. Weber, G. Audi, D. Beck, K. Blaum, G. Bollen, F. Herfurth, A. Kellerbauer, H.-J. Kluge, D. Lunney, S. Schwarz
Eur. J. Phys. A 25, s01, 201-202 (2005).

22. **Commissioning and first on-line test of the new ISOLTRAP control system**
C. Yazidjian, D. Beck, K. Blaum, H. Brand, F. Herfurth, and S. Schwarz
Eur. J. Phys. A 25, s01, 67-68 (2005).

21. **Mass measurements on the *rp*-process waiting point ^{72}Kr**
D. Rodríguez, V.S. Kolhinen, G. Audi, J. Äystö, D. Beck, K. Blaum, G. Bollen, F. Herfurth, A. Jokinen, A. Kellerbauer, H.-J. Kluge, M. Oinonen, H. Schatz, E. Sauvan, and S. Schwarz
Eur. J. Phys. A 25, s01, 41-43 (2005).

20. **Extending the mass "backbone" to short-lived nuclides with ISOLTRAP**
C. Guénaut, G. Audi, D. Beck, K. Blaum, G. Bollen, P. Delahaye, F. Herfurth, A. Kellerbauer, H.-J. Kluge, D. Lunney, S. Schwarz, L. Schweikhard, and C. Yazidjian
Eur. J. Phys. A 25, s01, 35-36 (2005).

19. **Is *N*=40 magic? An analysis of ISOLTRAP mass measurements**
C. Guénaut, G. Audi, D. Beck, K. Blaum, G. Bollen, P. Delahaye, F. Herfurth, A. Kellerbauer, H.-J. Kluge, D. Lunney, S. Schwarz, L. Schweikhard, and C. Yazidjian
Eur. J. Phys. A 25, s01, 33-34 (2005).

18. **Recent high-precision mass measurements with the Penning trap spectrometer ISOLTRAP**
F. Herfurth, G. Audi, D. Beck, K. Blaum, G. Bollen, P. Delahaye, S. George, C. Guénaut, A. Herlert, A. Kellerbauer, H.-J. Kluge, D. Lunney, M. Mukherjee, S. Rahaman, S. Schwarz, L. Schweikhard, C. Weber, and C. Yazidjian
Eur. J. Phys. A 25, s01, 17-21 (2005).

17. **Laser ionization and Penning trap mass spectrometry – A fruitful combination for isomer separation and high-precision mass measurements**
K. Blaum, D. Beck, G. Bollen, P. Delahaye, C. Guénaut, F. Herfurth, A. Kellerbauer, H.-J. Kluge, U. Köster, D. Lunney, S. Schwarz, L. Schweikhard, and C. Yazidjian
Proceedings of the V Int. Workshop on "Prospects for the development of laser methods in the study of nuclear matter", Poznan/Poland 2004
Hyp. Int. 162, 173-179 (2005).

16. **ISOLTRAP pins down masses of exotic nuclides**
K. Blaum, G. Audi, D. Beck, G. Bollen, M. Brodeur, P. Delahaye, S. George, C. Guénaut, F. Herfurth, A. Herlert, A. Kellerbauer, H.-J. Kluge, D. Lunney, M. Mukherjee, D. Rodríguez, S. Schwarz, L. Schweikhard, and C. Yazidjian
J. Phys. G 31, S1775-S1778 (2005).

15. **Mass measurements of $^{56-57}$Cr and the question of shell reincarnation at *N*=32**
C. Guénaut, G. Audi, D. Beck, K. Blaum, G. Bollen, P. Delahaye, F. Herfurth, A. Kellerbauer, H.-J. Kluge, D. Lunney, S. Schwarz, L. Schweikhard, and C. Yazidjian
J. Phys. G 31, S1765-S1770 (2005).

14. **ISOLTRAP mass measurements of exotic nuclides at $\delta m/m = 10^{-8}$**
K. Blaum, G. Audi, D. Beck, G. Bollen, P. Delahaye, S. George, C. Guénaut, F. Herfurth, A. Herlert, A. Kellerbauer, H.-J. Kluge, D. Lunney, M. Mukherjee, S. Schwarz, L. Schweikhard, and C. Yazidjian
Nucl. Phys. A 752, 317c-320c (2005).

13. **Mass spectrometry of atomic ions produced by in-trap decay of short-lived nuclides**
A. Herlert, D. Beck, K. Blaum, F. Carrel, P. Delahaye, S. George, C. Guénaut, F. Herfurth, A. Kellerbauer, H.-J. Kluge, D. Lunney, M. Mukherjee, L. Schweikhard, and C. Yazidjian
New J. Phys. 7, 44, 1-11 (2005).

2004:

12. **Towards high-precision mass measurements on ^{74}Rb for a test of the CVC hypothesis and the unitarity of the CKM matrix**
A. Kellerbauer, G. Audi, D. Beck, K. Blaum, G. Bollen, P. Delahaye, F. Herfurth, H.-J. Kluge, V. Kolhinen, M. Mukherjee, D. Rodríguez, and S. Schwarz
Nucl. Phys. A 746, 635c-638c (2004).

11. **Masses along the rp-process path and large scale surveys on Cu, Ni and Ga with ISOLTRAP**
F. Herfurth, G. Audi, D. Beck, K. Blaum, G. Bollen, P. Delahaye, C. Guénaut, A. Kellerbauer, H.-J. Kluge, D. Lunney, D. Rodríguez, S. Schwarz, L. Schweikhard, G. Sikler, and C. Yazidjian
Nucl. Phys. A 746, 487c-492c (2004).

10. **Recent results from the Penning trap mass spectrometer ISOLTRAP**
K. Blaum, G. Audi, D. Beck, G. Bollen, P. Delahaye, C. Guénaut, F. Herfurth, A. Kellerbauer, H.-J. Kluge, D. Lunney, D. Rodríguez, S. Schwarz, L. Schweikhard, C. Weber, and C. Yazidjian
Nucl. Phys. A 746, 305c-310c (2004).

9. **Trapping Radioactive Ions**
H.-J. Kluge and K. Blaum
Nucl. Phys. A 746, 200c-205c (2004).

8. **Mass measurement on the *rp*-process waiting point ^{72}Kr**
D. Rodríguez, V.S. Kolhinen, G. Audi, J. Äystö, D. Beck, K. Blaum, G. Bollen, F. Herfurth, A. Jokinen, A. Kellerbauer, H.-J. Kluge, M. Oinonen, H. Schatz, E. Sauvan, and S. Schwarz
Phys. Rev. Lett. 93, 161104 (2004).

7. **The mass of ^{22}Mg**
M. Mukherjee, A. Kellerbauer, D. Beck, K. Blaum, G. Bollen, F. Carrel, P. Delahaye, J. Dilling, S. George, C. Guénaut, F. Herfurth, A. Herlert, H.-J. Kluge, U. Köster, D. Lunney, S. Schwarz, L. Schweikhard, and C. Yazidjian
Phys. Rev. Lett. 93, 150801 (2004).

6. **Mass measurement of radioactive isotopes**
H.-J. Kluge, K. Blaum, C. Scheidenberger
Nucl. Instrum. Methods A 532, 48-55 (2004).

5. **Population inversion of nuclear states by a Penning trap mass spectrometer**
K. Blaum, D. Beck, G. Bollen, P. Delahaye, C. Guénaut, F. Herfurth, A. Kellerbauer, H.-J. Kluge, D. Lunney, S. Schwarz, L. Scheikhard, and C. Yazidjian
Europhys. Lett. 67, 586-592 (2004).

4. **Direct mass measurements on the superallowed emitter ^{74}Rb and its daughter ^{74}Kr: Isospin-symmetry-breaking correction for Standard-Model tests**
A. Kellerbauer, G. Audi, D. Beck, K. Blaum, G. Bollen, B.A. Brown, P. Delahaye, C. Guénaut, F. Herfurth, H.-J. Kluge, D. Lunney, S. Schwarz, L. Schweikhard, and C. Yazidjian
Phys. Rev. Lett. 93, 072502 1-4 (2004).

3. **A new control system for ISOLTRAP**
D. Beck, K. Blaum, H. Brand, F. Herfurth, and S. Schwarz
Nucl. Instrum. Methods A 527, 567-579 (2004).

2. **Unambiguous identification of three β-decaying isomers in ^{70}Cu**
J. Van Roosbroeck. C. Guénaut, G. Audi, D. Beck, K. Blaum, G. Bollen, J. Cederkall, P. Delahaye, H. De Witte, D. Fedorov, V.N. Fedoseyev, S. Franchoo, H. Fynbo, M. Gorska, F. Herfurth, K. Heyde, M. Huyse, A. Kellerbauer, H.-J. Kluge, U. Köster, K. Kruglov, D. Lunney, A. De Maesschalck, V.I. Mishin, W.F. Müller, S. Nagy, S. Schwarz, L. Schweikhard, N.A. Smirnova, K. Van de Vel, P. Van Duppen, A. Van Dyck, W.B. Walters, L. Weissmann, and C. Yazidjian
Phys. Rev. Lett. 92, 112501 1-4 (2004).

1. **Study of ground- and low-lying nuclear states by combining laser ionization and Penning trap mass spectrometry**
K. Blaum, D. Beck, G. Bollen, P. Delahaye, C. Guénaut, F. Herfurth, A. Kellerbauer, H.-J. Kluge, U. Köster, D. Lunney, S. Schwarz, L. Schweikhard, and C. Yazidjian
Proceedings of the XXXII Int. Workshop on “Gross Properties of Nuclei and Nuclear Excitations”
Hirschegg/Austria 2004, GSI Report, ISSN 0720-8715, 183-188 (2004).

List of PhD Theses 2004-2009

In preparation

C. Borgmann, MPI for Nuclear Physics, Heidelberg, Germany

S. Naimi, Université Denis Diderot, Paris 7, France

D. Neidherr, Johannes Gutenberg-Universität, Mainz, Germany

M. Breitenfeldt, Ernst-Moritz-Arndt-Universität, Greifswald, Germany

E. Minaya Ramirez, Université de Paris Sud, Orsay, France

2009

Study of the effects of valence proton-neutron interactions in atomic nuclei (submitted)
B. Cakirli
Istanbul University, Department of Physics, Istanbul, Turkey

First Ramsey-type mass measurements with ISOLTRAP and design studies of the new PENTATRAP project (submitted)
S. George
Johannes Gutenberg-Universität, Mainz, Germany

2008:

Precision mass measurements on neutron-rich Zn isotopes and their consequences on the astrophysical r-process
S. Baruah
Ernst-Moritz-Arndt-Universität, Greifswald, Germany

2006:

A new detector setup for ISOLTRAP and test of the isobaric multiplet mass equation
C. Yazidjian
Université de Caen, Caen, France

2005:

Optimized ion trapping of exotic nuclides for mass measurements in the N=40 (magic?) region
C. Guénaut
Université de Paris Sud, Orsay, France

First on-line mass measurements at SHIPTRAP and mass determinations of neutron-rich Fr and Ra isotopes at ISOLTRAP
S. Rahaman
Ruprecht-Karls-Universität, Heidelberg, Germany

2004:

The mass of ^{22}Mg and a concept for a novel laser ion source trap
M. Mukherjee
Ruprecht-Karls-Universität, Heidelberg, Germany

Konzeption eines kryogenen Penningfallenaufbaus für SHIPTRAP und Massenbestimmung von Radionukliden um den Z=82–Schalenabschluss an ISOLTRAP
C. Weber
Ruprecht-Karls-Universität, Heidelberg, Germany

List of Diploma Theses 2004-2009

In preparation
M. Rosenbusch, Ernst-Moritz-Arndt-Universität, Greifswald, Germany

2009:

Setup of a carbon-cluster laser ion source and the application of the invariance theorem at ISOLTRAP
Ch. Böhm,
Johannes Gutenberg-Universität, Mainz, Germany

2006:

Optimierung der Zyklotronfrequenzbestimmung und Hochpräzisionsmassenmessungen an neutronenreichen Zinnisotopen mit ISOLTRAP
M. Dworschak
Bayerische Julius-Maximilians-Universität, Würzburg, Germany

2005:

Anregungs- und Nachweismethoden von Ionenbewegungen in Penningfallen
M. Breitenfeldt
Ernst-Moritz-Arndt-Universität, Greifswald, Germany

Application of the Ramsey method in high-precision Penning trap mass spectrometry
S. George
Universität Münster, Münster, Germany

Stabilisation en pression et en température du champ magnétique dans le piège à ions de précision d'ISOLTRAP au CERN
M. Marie-Jeanne
ENSI de Caen et Université de Caen, Caen, France

2004:

Améliorations des performances d'ISOLTRAP
F. Carrel
ENSI de Caen et Université de Caen, Caen, France