

Antimatter Research in Hungary

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Outline

- Wigner RCP, Budapest and Atomki, Debrecen
- Antiproton Studies, 1989-2016
- The Hungarian Group

Wigner RCP

Wigner Research Centre for Physics of the Hungarian Academy of Sciences, Budapest: two research institutes, 360 employees (210 researchers) + > 100 students and associates (active retired colleagues)

- Institute for Particle and Nuclear Physics
Departments: Theory, High Energy Ph., Plasma Ph., Space Ph., Nuclear Methods in Materials Sc., Rehabilitation Technology, LHC Grid T2 Station
- Institute for Solid State Physics and Optics
Departments: Theory, Applied Optics, Quantum Optics, Expt. Solid State, Neutron Spectroscopy
- Central Service Groups
Wigner Data Centre (LHC Grid Tier-0), Campus Network, Library, Technical Base

Atomki

Institute of Nuclear Research (Atomki) of the Hungarian Academy of Sciences, Debrecen: 206 employees (87 researchers) + > 50 students and associates (active retired colleagues)

Departments:

- Nuclear Ph.: Expt., Theory, Ion Beam Ph.
- Atomic Ph.: Collisions, Spectroscopy
- Applied Ph.: Environment, Accelerator, Electronics

Hungary in Antimatter Business – 1

- *Anticyclotron tests (LEAR, 1989-93)*, D. Horváth et al. (incl. I. Krafcsik): „Deceleration of MeV antiprotons and muons to keV energies — the anticyclotron”
Nucl. Instr. Meth. B 85 (1994) 736–740.
- *Antihydrogen (Feasibility Study to SPSC, 1993)*, M. Charlton, J. Eades, D. Horváth, R. J. Hughes, C. Zimmermann: „Antihydrogen physics”, **Physics Reports 241 (1994) 65–117.**
- *Laser Spectroscopy on Antiprotonic Helium (LEAR, 1990-96)*
 - N. Morita et al.: „First observation of laser–induced resonant annihilation in metastable antiprotonic helium atoms”
Phys. Rev. Lett. 72 (1994) 1180–1183.
 - H. A. Torii *et al.*, „High precision laser measurements of the density shifts of resonance lines in anti-protonic helium atoms and stringent constraint on the anti-proton charge and mass”,
Phys. Rev. A 59 (1999) 223.

Hungary in Antimatter Business – 2

- *Laser Spectroscopy on Antiprotonic Helium (AD, 1999–)*
 - R. S. Hayano, M. Hori, D. Horváth and E. Widmann, „Antiprotonic helium and CPT invariance”, Rept. Prog. Phys. 70 (2007) 1995.
 - M. Hori, A. Sótér, D. Barna, A. Dax, R.S. Hayano, S. Friedreich, B. Juhász, T. Pask, E. Widmann, D. Horváth, L. Venturelli, N. Zurlo: „Two-photon laser spectroscopy of antiprotonic helium and the antiproton-to-electron mass ratio”, Nature 475 (2011) 484
 - M. Hori , H. Aghai-Khozani, A. Sótér, D. Barna, A. Dax, R. Hayano, T. Kobayashi, Y. Murakami, K. Todoroki, H. Yamada, D. Horváth, L. Venturelli:
„Buffer-gas cooling of antiprotonic helium to 1.5 to 1.7 K, and antiproton-to-electron mass ratio”, Science 354 (2016) no.6312, 610.

Hungary in Antimatter Business – 3

● *Preparation of an Antihydrogen Beam*

- N. Kuroda, H.A. Torii, K. Yoshiki Franzen, Z. Wang, S. Yoneda, M. Inoue, M. Hori, **B. Juhász**, **D. Horváth**, H. Higaki, A. Mohri, J. Eades, K. Komaki, Y. Yamazaki:
„Confinement of a Large Number of Antiprotons and Production of an Ultraslow Antiproton Beam”,
Phys. Rev. Lett. **94** (2005) 023401.

● *Magnetic moment of \bar{p}*

- S. Friedreich, **D. Barna**, F. Caspers, A. Dax, R.S. Hayano, M. Hori, **D. Horváth**, **B. Juhász**, T. Kobayashi, O. Massiczek, **A. Sótér**, K. Todoroki, E. Widmann, J. Zmeskal:
„First observation of two hyperfine transitions in antiprotonic ^3He ”,
Physics Letters B **700** (2011) 1-6.

Hungarian Group: R.I.P.

- **Bertalan Juhász**: MSc and PhD in Debrecen, was PD at SMI, Vienna, now at airberlin. In ASACUSA 1999-2012.
- **Bálint Radics**: MSc in Debrecen, PhD in Bonn, PD in Budapest then at ASACUSA (RIKEN), now at ETHZ. In ASACUSA 2014-16.
- **Dániel Barna**: MSc and PhD in Budapest, PD at ASACUSA (RIKEN, U Tokyo and CERN), now works for FCC at Wigner RCP. In ASACUSA 2004-2016, in ELENA 2013-16.
- **D. Horváth**: 60% CMS, 40% ASACUSA, but no grant neither students for ASACUSA after Aug. 2017.
- **Anna Sótér**: MSc in Budapest, PhD in Munich, now PD at MPQ. In ASACUSA since 2008.
- **Csaba Hajdu**: In CMS, not in ASACUSA, operates and develops the WLCG Tier-2 at Wigner. Willing to accept students for Grid.