

PERSONAL INFORMATION

Family name, First name: Vacchi, Andrea (9th December 1951, Italian)

Researcher unique identifier: orcid.org/0000-0003-3855-5856; ResearcherID: C-1291-2010

EDUCATION

1976 Degree in Physics, University of Bologna, Italy; Highest marks and honors

CURRENT POSITION

Since 10/2017 - **Full extr. Prof. Experimental Physics** Dep. Math. Inform. Phys. Udine University

PREVIOUS POSITIONS AND FELLOWSHIPS

2014 – 2019 **Visiting Scientist** - Advanced Meson Science Laboratory - **RIKEN Nishina Center** for Accelerator-Based Science, **Wako, Saitama, Japan**

1997 - 10/2017 **Director of Research**, Istituto Nazionale di Fisica Nucleare (INFN), Trieste Division

1990 – 1997 **Senior Researcher** - **INFN Trieste Division**, Italy

1990 – 1991 **Visiting Professor** - Physics Department - **Rockefeller University NY USA**

1987 – 1990 **Assistant Professor**, Physics Dep. Rockefeller University NY USA working at CERN

1986 – 1987 **Senior Researcher**, Physics Dep. Rockefeller University NY USA working at CERN

1983 – 1985 **Senior Fellow**, Exp. Physics Division - **CERN**

1982 – 1983 **Research Associate**, Physics Dep. Rockefeller University NY USA working at CERN

1977 – 1982 **Research Scientist**, ETH-PSI Swiss Federal Institute of Technology ETH Swiss.

MAIN INSTITUTIONAL RESPONSIBILITIES

Since 2011 Board of financing agencies, Neutrino factory experiment MICE Rutherford laboratory, UK

2012 – 2016 **Board of Directors** of the International School for Advanced Studies (SISSA), Trieste

2012 – 2016 **Chair National Technology Transfer Board** of the INFN

2012 – 2016 **President of FIT**, the International Trieste Foundation for the future of sciences

2010 – 2011 **Board of directors** of the GARR, Italian Academic-Research telecommunication Network

2010 – 2011 **INFN/MIUR Delegate** in the European Project **ELI - Extreme Light Infrastructure**

2009 – 2011 **Executive Board Member** of INFN

2007 – 2011 **Scientific Board Chair & Editorial Director** of the INFN review **ASIMMETRIE**

2003 – 2008 **Director** of the INFN Trieste division

2000 – 2003 **Chair of the INFN National Scientific Board**, CSN 5 for R&D.

MAIN RESPONSIBILITIES IN COORDINATION OF RESEARCH AND PROJECTS

2015 – **Responsible of the XAFS Silicon Drift Detectors (SDD) development** within **SESAME** (*Synchrotron-light for Experimental Science and Applications in the Middle East* - Jordan)

since 2013 **Principal investigator** of FAMU experiment (muonic hydrogen precision spectroscopy)

2010–2013 **Principal investigator** of FAMU-RD experiment (muonic hydrogen precision spectroscopy)

2004-2010 **Principal investigator** of QCL-MUH Quantum Cascade Lasers QCL - MUonic - Hydrogen

since 2012 **Responsible of the SDD Detectors development** within the Collaboration EUROFEL

2010 – 2013 **Italian Principal investigator** of the GAMMA400 space satellite experiment

since 2009 **Member** of LOFT Consortium Council (X-ray astrophysics proposals)

since 2008 **Principal investigator** of XDXL-REDSOX developing SDD for X-ray astrophysics & ALS

1994 – 2011 **Coordinator** for the development of SDD for the tracking system of CERN LHC ALICE

1994 – 1998 **Project manager** of the satellite Wizard-NINA, first successful INFN CR satellite (1997)

1993 – 2011 **Member of the scientific committee PAMELA** Cosmic Ray satellite

1982 – 1993 CERN UA6 experiment SppS collider TRD detector development

1977 – 1982 ETHZ PSI **muonic atoms**, Bragg crystal spectrometer

MENTORING ACTIVITIES

In the last years I had leading roles in various experiments, some of them with very significant scientific results and evolutions (e.g. PAMELA, ALICE, REDSOX SDD-EXTP, FAMU). As a consequence I was involved with the work and supervised a large number of young researchers active in those projects. Some had shining career.

TEACHING ACTIVITIES

Since – 2014 **Professor** of Experimental Physics at University of Udine: II and III level Physics course.

1978 – 1982 Teaching Assistant - Physics course Engineering Department, **ETH Zurich Switzerland**.

Throughout the years I have given lectures and courses at various levels, most recently:
2016 and 2017 physics lectures - Scuola Superiore of Udine University.

ORGANISATION OF SCIENTIFIC MEETINGS (selection)

9-11/05/16 **Co-chair**, 2nd Meeting on Silicon Drift Detectors for Low Energy X-Ray Application, Palazzo Natta, COMO (I) 30 participants.

13-17/05/15 **Organizer** Workshop on Off-the-Beaten-Track Dark Matter and Astrophysical Probes of Fundamental Physics. ICTP Trieste, Italy

25-27/08/14 **Director & organizer** - GEOTHERMAL ENERGY: Status and Future in the Peri-Adriatic Area Veli Lošinj, Croatia,; 60 participants.

22-26/06/14 **Organizing Committee** - International Workshop on Radiation Imaging Detectors iWoRID Trieste - Italy; 230 participants.

1-4/05/13 **Co-chair & organizer**: Workshop Science with GAMMA400, ICTP . 50 participants;

12-23/11/12 **Organizer** - Workshop on Recent Developments in Astro-nuclear and Astro-particle Physics ICTP; 60 participants.

18-24/9/16. **LOC** "Cosmic Ray Origin - beyond the standard models" San Vito di Cadore Italy

10-14/10/2016 ICPPA 2016 **International Advisory Committee member** The Second International Conference on Particle Physics and Astrophysics Moscow, Russia

COMMISSIONS OF TRUST / MEMBERSHIPS OF SCIENTIFIC SOCIETIES

Since 2008 – present **Coordinator of the Scientific Technical Advisory Board** for the Material-Microsystem Centre CMM of Bruno Kessler Foundation **FBK**, Trento, Italy.

2011&13 **Reviewer** - Accelerator and Detector R&D Program of the Scientific User Facilities Division, Office of Sciences, DOE; USA.

2010-13 **Member** OECD Experts Group on International Distributed Research Infrastructures (IDRIS)

2005 – 2006 **Member GSI FAIR** cost-review CORE-E at FAIR accelerator at GSI in Darmstadt (BRD).

Member of : *Società Italiana di Fisica SIF*; *World Academy of Sciences and Arts WAAS* (USA); *Instrumentation and Measurement Society IEEE* (USA).

RESEARCH PERFORMANCE (Source: INSPIRE)

Co-author of >330 citable papers, with a total of > 10000 citations; >200 articles are from the last 10 years, 12 having more than 250 and two more than 1000 citations; H-index = 47.

TALKS (selection)

"Towards the measurement of the hyperfine transition in muonic hydrogen"

Nucleon Spin Structure at Low Q: A Hyperfine View

ECT* - European Centre for Theoretical Studies in Nuclear Physics

July 2-6, 2018 Trento, Italy

"The FAMU experiment: Spectroscopy of the 1S HFS transition in muonic hydrogen

Determination of the Zemach radius of the proton"

EUrepan Nclear Physics Conference Bologna 2-9 September 2018

"Development and performance of large area Silicon-drift detectors SDD and their potentials for low energy x-ray detection in synchrotron light sources & astrophysics"

High Precision X-ray Measurements 2018 LNF 17-19/10/2018

09/2017 **"The proton charge radius and Precision spectroscopy in Muonic Hydrogen"** Invited talk

Italian Physical Society 103rd National Congress Section 1 Nuclear and Subnuclear Physics Trento

10/2017 **"Development and Performance of Advanced Room Temperature Solid State Drift**

Detectors and Electronics in Synchrotron Radiation, X-ray Astronomy and Astrophysics" Invited

talk 24th International Workshop on Room Temperature Semiconductor Detectors Atlanta Georgia USA

26/06/16 **"Development and performance of Si-drift-based detectors and their potential capability for x-ray astrophysics,"** invited: SPIE Astronomical Telescopes and Instrumentation, Edinburgh, UK

19/06/16 **"Muonic hydrogen ground state hydrogen Hyperfine splitting - towards the high precision measurement"** 2nd ECT* Workshop on the Proton Radius Puzzle Trento Italy

22/05/16 **" Towards the high precision measurement of the hyperfine splitting of muonic hydrogen in the ground state"** PSAS'2016: International Conference on Precision Physics of Simple Atomic

Systems Hebrew University of Jerusalem, Jerusalem, Israel

09/01/15 **"Measurement of the muon transfer rate from proton to heavier nuclei at epithermal energies"**, 11th Program Advisory Committee Meeting RIKEN Nishina Center Japan

Ten years track record

The common thread in my career as an experimental physicist is the interest in muonic atoms high precision physics, that begun in the early days of the thesis at CERN SC and first job as a researcher at ETHZ-PSI and culminated with the quest for a way **to measure the hyperfine splitting in muonic hydrogen** which needed though more lengthy technology developments. Meanwhile being attracted by the physics of cosmic rays and the development of cutting edge detection systems, I assumed significant responsibilities in the coordination of experiments that have yielded world-class results within **Cosmic Rays high precision rear events search (PAMELA) and accelerators (ALICE, LHC)**. I developed specific semiconductor detectors technology, giving substantial momentum to X-ray Astrophysics, advanced light sources detector-systems.

In recent years I led the FAMU experiment for the **measurement of the muonic hydrogen atoms $\Delta E^{\text{hfs}}(\mu^-p)_{1S}$ transition**.

Muonic atoms physics

Simple atoms, such as **muonic hydrogen** provide effective testing ground for fundamental theories. In order to demonstrate the experimental feasibility of the proposed approach to the measurement of the $\Delta E^{\text{hfs}}(\mu^-p)_{1S}$ transition, at the end of a long and accurate preparation and study phase, I initiated in 2012 a concrete effort in relation to the needed *mid infrared laser (MIR)* having a sufficient energy output and to detectors characterization at an *intense pulsed muon beam* [1-6]. The work is being carried out in all the strategic directions. This has allowed to proof the key technology of the MIR laser system, of the beam-target-detector and to verify the details of the muon transfer mechanism. Today we are ready to build the appropriate laser-target-detector system. The basic aim is to expand the knowledge on the static and dynamic structure of the proton through a new approach to high precision muonic atoms spectroscopy, using pulsed intense muon beams. Despite considerable challenges the measurement of $\Delta E^{\text{hfs}}(\mu^-p)_{1S}$ to improve the knowledge of the internal structure of proton and has been for me a constant target through the years. This theme has been recently put in a new perspective by the so-called *Proton Radius Puzzle* caused by a relevant (about 4%) unexplained discrepancy between the values of the **proton charge radius** obtained from measurements with different probes and techniques; scattering and atomic spectroscopy with electrons and muons.

Cosmic Rays experiments

I played a leading role in the developments and realization of the satellite magnetic spectrometer **PAMELA**, aimed at the direct observation of antimatter in cosmic rays. This experiment was initiated in 1990 when I came back to Italy to give body to this effort with the use of the recently developed technology of silicon detectors. Since its launch in 2006, the PAMELA satellite has collected data of great significance [7,8,9] in the field of high precision rear CR events search. PAMELA represents a peak of my experimental work in this area. While taking part to the central coordination of the whole project, I guided a team responsible for the realization of the silicon tungsten tracking-calorimeter and playing a decisive role in the data analysis. **PAMELA's harvest of results represents a milestone in the modern high precision study of cosmic rays**. The absolute flux of primary galactic cosmic rays has been precisely measured for the first time, together with secondary cosmic rays antiparticles in particular antiproton and positrons. The possible explanation of the measured excess in the **positron spectra at high energy as a dark matter indicator** has awakened a persistent interest, this is shown by the more than 1800 quotations of the work [7]. PAMELA and its calorimeter have been successfully in orbit for almost ten years, much longer than foreseen.

Detectors, ALICE, Low-energy X-ray astrophysics and advanced light sources

Very early after the invention of Silicon Drift Detectors (SDD), I started collaborating with the inventors on the development of this intriguing detector, featuring high position and energy resolution and unambiguous particles track identification. I underline here that these detectors are ideal for **muonic hydrogen spectroscopy (whose 2P-1S line is at about 2 KeV), this aspect was not secondary in my motivation to work in this field**. Successively I led an effort to develop large area SDD that are able to work in the harsh conditions of the ALICE-LHC experiment. Since 2007 the **largest area SDD detector built up to now was implemented in the inner tracking system of ALICE** [10]. Up to decommissioning this system has been still perfectly operational. This has been achieved thanks to the highly skilled team of researchers that I had the possibility to build in Trieste. On the basis of these

results, in 2009 I have suggested a new application of SDD in low energy x-ray astrophysics (LOFT; e-XTP): the demonstrated performances of our detector will allow a significant quality and sensitivity leap. The primary astrophysical purposes are to explore the state of matter at supra nuclear densities in Neutron Stars and the gravity theory in the very strong field environment of Black Holes. Meanwhile cutting edge proposals for the application in astrophysics of this detector concept are being discussed. Recently state of the art results on high resolution low energy X-ray SDD operating at room temperature have been published. With the intention to further value this useful technology, I began a collaboration that includes the synchrotron light laboratory Sincrotrone Trieste (I), suggesting to develop specific beam-line dedicated high-energy resolution SDD. The positive results obtained allowed our team to be selected for the realization of an advanced detector system for the SESAME synchrotron light accelerator in Jordan.

Research management, technology transfer, outreach

In the last ten years, as a consequence of my *research experience and high level institutional management responsibility roles* that I had at INFN and beyond, I had the opportunity to be active on themes complementary to research, such as technology transfer and outreach activities. As chair of the INFN National Technology Transfer Board, I realized a national network with a central-reference and support-pole. This organization is able to promote partnerships with enterprises and fetch the local and international projects opportunities (as for instance within H2020), to steer the technology research advancements towards markets and industrial product innovation, flanking researchers in patenting and spin-off procedures.—Concerning outreach I contributed as chair of the scientific board and editorial director to the INFN scientific outreach monographic journal ASIMMETRIE, addressed to high school students, by giving it a completely new structure, look and content .

Selected Publications:

- [1] **Steps towards the hyperfine splitting measurement of the muonic hydrogen ground state**
A. Adamczak et. al. Journal of Instrumentation, Volume 11, P05007, May 2016
- [2] **Hyperfine spectroscopy of muonic hydrogen and the PSI Lamb shift experiment**
A. Adamczak, D. Bakalov, L. Stoychev, A. Vacchi. 2012. 5 pp. Nucl.Instrum.Meth. B281 (2012) 72-76.
- [3] **DFG-based mid-IR laser system for muonic-hydrogen spectroscopy.**
Stoychev, L. I. *et al.* in **9135**, 91350J (International Society for Optics and Photonics, 2014)
- [4] **Theoretical and computational study of the energy dependence of the muon transfer rate from hydrogen to higher- Z gases** Dimitar Bakalov, Andrzej Adamczak, Mihail Stoilov, Andrea Vacchi
Phys.Lett. A379 (2014) 151-156
- [5] **Toward the measurement of the hyperfine splitting in the ground state of muonic hydrogen** D. Bakalov, A. Adamczak, M.Stoilov, A. Vacchi Hyperfine Interact. 233 (2015) no.1-3, 97-101
- [6] **First FAMU observation of muon transfer from mu-p atoms to higher-Z elements.** E. Mocchiutti et.al. *ArXiv170803172 Phys.* (2017)
- [7] **An anomalous positron abundance in cosmic rays with energies 1.5-100 GeV**
PAMELA Collaboration Oscar Adriani *et al.* Oct 2008. 20 pp. Nature 458 (2009) 607-609. Cit. >1690
- [8] **A new measurement of the antiproton-to-proton flux ratio up to 100 GeV in the cosmic radiation** O. Adriani *et al.*. Oct 2008. 11 pp. Published in Phys.Rev.Lett. 102 (2009) Cit. >520
- [9] **PAMELA Measurements of Cosmic-ray Proton and Helium Spectra** PAMELA Collaboration (O. Adriani *et al.*. Mar 2011. 13 pp. Published in Science 332 (2011) 69-72 Cit. >300 records
- [10] **The ALICE experiment at the CERN LHC** ALICE Collaboration (K. Aamodt (Oslo U.) *et al.*). 2008. 259 pp. Published in JINST 3 (2008) Cit.> 1274 records

Udine 24 February 2020

Andrea Vacchi

