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EDUCATION

Pursuing scientific research and innovation

The Christian Doppler Laboratory

Christian Doppler Forschungsgesellschaft (Christian Doppler Research Association) is an eminent society promoting collaboration between science and industry. The Christian Doppler Laboratory symbolises impeccable scientific research and innovation. It encourages Austrian universities and research institutions to share knowledge and expertise with Austrian and international industrial corporations. It expects collaboration to establish long term intellectual and economic advantages. Research has concentrated on eight academic disciplines considered important for academia and industry. Three examples of research conducted at the laboratories provide a glimpse of the impact of the partnership.

Christian Doppler was a distinguished Austrian physicist and mathematician. He was born on 29 November 1803 in Stadt Salzburg. He completed high school and studied philosophy in Salzburg before studying mathematics and physics at Vienna University of Technology. Doppler published *Über das farbige Licht der Doppelsterne und einiger anderer Gestirne des Himmels* (*On the coloured light of the binary stars and some other stars in the heavens*) in 1842. The Doppler effect is revealed in the publication. He advocated the observed frequency of a source depends on its relative velocity to the observer. Doppler considered light and sound as longitudinal waves in ether and matter. Doppler was incorrect in stating light was a longitudinal wave. It did not affect the principle. The Doppler effect remains an important scientific theory. It has applications for radar, sirens, astronomy, medical imaging, blood flow measurement, satellite communication, audio, velocity profile measurement, vibration measurement and developmental biology.

The Österreichische Industrieholding AG (ÖIAG) established the Christian Doppler Research Association. The association was created in 1988 to pursue basic research at the highest level. Research was dedicated to provide medium and long term benefits for participating corporations. The Österreichische Industrieholding AG was transformed from an industrial group to an investment agency in 1993. The changes permitted all Austrian corporations to participate in the Christian Doppler Research Association. The Bundesministerium für Wissenschaft, Forschung und Wirtschaft (Austrian Ministry for Science, Research and the Economy) assumed authority of the agency.

Demand for Christian Doppler Laboratories continues to increase. 129 commercial partners were involved in Christian Doppler Laboratories in 2014. Austrian commercial partners comprised 67 large corporations and 26 small and medium enterprises. Foreign commercial

partners comprised 32 large corporations and 4 small and medium enterprises. Seventy-one laboratories were active in 2014 managing 840 employees. Sixty-six laboratories were based at 16 Austrian universities and research institutions. The budget for a laboratory is between EUR 110,000 and EUR 700,000 annually. The Austrian Ministry for Science, Research and Economics and Nationalstiftung für Forschung, Technologie und Entwicklung (National Foundation for Research, Technology and Development) provide public finance. Corporations provide finance as industrial partners. Research yielded 420 academic publications in 2014. Peer reviewed scientific periodicals accounted for 320 publications. Academics provided 1123 presentations at conferences in 2014. The presentations consisted of 212 peer reviewed and 202 invited presentations. Academics were granted 13 patents during the period.

Josef Ressel Centres are laboratories dedicated to the requirements for universities of applied science. Josef Ressel was an Austrian inventor acknowledged for designing a functional ship propeller. The budget ranges from EUR 80,000 to EUR 400,000 annually. The Austrian Ministry for Science, Research and the Economy and corporate partners provide finance for the research. Five Josef Ressel Centres were operating in 2014 at Fachhochschule Kärnten, Fachhochschule Salzburg, Fachhochschule Vorarlberg, Fachhochschule Oberösterreich and Fachhochschule Technikum Wien. Research at the centres concentrated on the disciplines of mathematics, computer science, electronics and non metal materials. Fifty personnel were employed at the centres in 2014.

Christian Doppler Laboratories provide the foundation for intellectual discovery and innovation. Universities and research institutes must pursue basic research at an advanced level. Seven years is the maximum duration of a laboratory. Universities and research institutes are integrated into the research environment. Scientists are guaranteed academic freedom to explore ideas, techniques and instruments. Small research groups consisting of five to fifteen personnel encourages greater co-operation. An academic is responsible for the chief position of the laboratory. Rigorous surveillance of scientific quality to ensure research occurs at the highest level. The principles governing the laboratories create a collaborative research environment dedicated to intellectual inquiry and development.

Eight research themes have become important in the evolution of the laboratory. The chemistry cluster examines manufacturing fuels from renewable energy. Research is also committed to improving existing technologies and materials. Life science and environment is dedicated to developing a greater understanding of cellular and biophysical processes. The industrial production of organic substances, developing new drugs or possible solutions to environmental problems are some of the topics explored in this cluster. The mechanical, engineering and instrumentation cluster investigates the use of machines and instruments to improve quality of life. Research concentrates on instruments to develop medicine and material diagnostics and improving machines. Mathematics, computer science and electronics focuses on optimising and expanding computer solutions. It also involves analysing specific mathematical or physical processes. Medicine is dedicated to improving diagnostic and treatment choices for human diseases. There is an emphasis on treating allergies, immune processes, inflammatory processes and specific oncological diseases.

Christian Doppler Laboratories offer universities and corporate partners intellectual and economic advantages. It provides participating partners the opportunity to develop new products and processes. Industrial corporations are able to accelerate the innovation process through the accumulation of scientific development and knowledge from laboratories. It increases the capacity of industrial partners to solve problems and create distinct competitive advantages. Universities enjoy the prospect of exceptional scientific research and increase in knowledge. The industrial partner provides finance for the duration of the laboratory. Both benefit from strategic alliances from conducting research.

A Christian Doppler Laboratory for automated software engineering at the Johannes Kepler University Linz developed software systems and tools. Between March 2006 and January 2013 the laboratory examined and developed concepts, methods and instruments for successful automation of critical software engineering tasks. Automated techniques are vital for software engineering to improve corporate quality and productivity. It yielded fifteen doctoral theses, thirty-six masters theses, 165 publications and three patents. Siemens AG, Keba AG, BMD Systemhaus GmbH and Siemens VAI were the industrial partners. The research resulted in some software systems and instruments becoming products.

Graz University of Technology received a Christian Doppler Laboratory for investigating advanced ferroic oxides. Between January 2008 and December 2014 researchers examined the development of ferroic materials for complex components in new applications. EPCOS, Europe's largest manufacturer of electronic components was the industrial partner in the research. Research concentrated on new synthesis and processing routes, improving understanding of charge transport phenomena, analysing interaction of different ferroic properties of materials and developing materials for high mechanical and electrical load. It yielded forty-four academic publications

A Christian Doppler Laboratory for thermodynamics of reciprocating engines conducted research at Graz University of Technology. Between September 2004 and August 2011 the laboratory assessed two reciprocating engines. Researchers used thermodynamics to analyse a hermetic piston compressor and a high speed two stroke engine. Researchers investigated the physical processes influencing engine function, heat transfer and friction loss. BRP Rotax and ACC Austria were the industrial partners. The research yielded thirty-eight academic publications.

A Christian Doppler Laboratory provides the ideal environment to conduct research and discover significant industrial and economic advantages. The Österreichische Industrieholding AG is determined Austrian research and industry maintains their elite global position. Austrian universities and research institutions are involved in the highest level of scientific research with the prospect of increasing their knowledge and expertise. Austrian and international industrial corporations benefit from developing new products, production techniques and solving industrial problems.