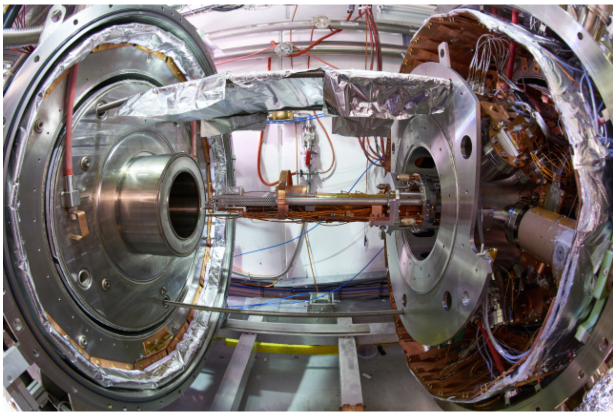
CERN meets quantum technology



The AEgIS 1T antimatter trap stack. CERN's AEgIS experiment is able to explore the multi-particle entangled nature of photons from positronium annihilation, and is one of several examples of existing CERN research with relevance to quantum technologies.

Today's information and communication technology grew out of the invention and development of quantum mechanics during the last century. But, nifty as it is that billions of transistors can be packed into your smartphone or that photons are routed around the internet with the help of lasers, the devices underpinning the "first quantum revolution" merely rely on the weird properties of quantum mechanics – they don't put them to use directly.

(Image: CERN)

The CERN Quantum Technology Initiative (QTI), which was announced by CERN Director-General Fabiola Gianotti in June, sees CERN join a rapidly-growing global effort to bring about a “second quantum revolution” – whereby phenomena such as superposition and entanglement, which enable an object to be in two places at the same time or to influence another instantaneously, are exploited to build new computing, communication, sensing and simulation devices.

It is difficult to predict the impact of such quantum technologies on society, but for high-energy physics and CERN the benefits are clear. They include advanced computing algorithms to cope with future data-analysis challenges, ultrasensitive detectors to search for hidden-sector particles and gravitational waves, and the use of well-controlled quantum systems to simulate or reproduce the behaviour of complex many-body quantum phenomena for theoretical research.

Though relatively new to the quantum technologies scene, CERN is in the unique position of having in one place the diverse set of skills and technologies – including software, computing and data science, theory, sensors, cryogenics, electronics and material science – necessary for such a multidisciplinary endeavour. AEgIS at CERN’s Antiproton Decelerator, which is able to explore the multi-particle entangled nature of photons from positronium annihilation, is one of several examples of existing CERN experiments already working in relevant technology areas. CERN also provides valuable use cases to help compare classical and quantum approaches to certain applications, as demonstrated recently when a team at Caltech used a quantum computer comprising 1098 superconducting qubits to “rediscover” the Higgs boson from LHC data. CERN’s rich network of academic and industry relations working in unique collaborations such as CERN openlab is a further strength.

The path to CERN’s QTI began with a workshop on quantum computing in high-energy physics organised by CERN openlab in November 2018, which was followed by several initiatives, pilot projects and events. During the next three years, the initiative will assess the potential impact of quantum technologies on CERN and high-energy physics on the timescale of the HL-LHC (late 2030s) and beyond. Governance and operational instruments are being finalised and concrete R&D objectives are being defined in the four main quantum technologies areas: computing; sensing and metrology; communication; and simulation and information processing. The CERN QTI will also develop an international education and training programme in collaboration with experts, universities and industry, and identify mechanisms for knowledge sharing within the CERN Member States, the high-energy physics community, other scientific research communities and society at large.

“By taking part in this rapidly growing field, CERN not only has much to offer, but also stands to benefit directly from it,” says Alberto Di Meglio, coordinator of the CERN QTI and head of CERN openlab. “The CERN Quantum Technology Initiative, by helping structure and coordinate activities with our community and the many international public and private initiatives, is a vital step to prepare for this exciting quantum future.”