

Viewpoint

In search of hidden light

Could the skills developed for the energy frontier also be focused on the cosmic frontier?



In my journey as a migrant scientist, crossing continents and oceans to serve physics, institutions and nations wherever and whenever I am needed and called upon, CERN has always been the focal point of illumination. It has been a second home to whichever institution and country I have been functioning from, particularly at times of major personal and professional transition. Today, at the completion of yet another major transition across the seas, I am beginning to connect to the community from my current home at Fermilab and Northern Illinois University. Eight years ago, I wrote in this column on “Amazing particles and light” (*CERN Courier* March 2007 p50) and, serendipitously, I am drawn by CERN’s role in shaping developments in particle physics to comment again in this International Year of Light, 2015.

“For the rest of my life I want to reflect on what light is!”, Albert Einstein exclaimed in 1916. A little later, in the early 1920s, S N Bose proposed a new behaviour for discrete quanta of light in aggregate and explained Planck’s law of “black-body radiation” transparently, leading to a major classification of particles according to quantum statistics. The “photon statistics” eventually became known as the Bose–Einstein statistics, predicting a class of particles known as “bosons”. Sixty years later, in 1983, CERN discovered the W and Z boson at its Super Proton Synchrotron collider, at what was then the energy frontier. In another 30 years, a first glimpse of a Higgs boson appeared in 2012 at today’s high-energy frontier at the LHC, again at CERN.

Today, CERN’s highest-priority particle-physics project for the future is the High-Luminosity LHC upgrade (*CERN Courier* March 2015 p28). However, the



Einstein, top, and Bose shared an affinity for strings: Einstein played the violin from childhood and Bose was a master on the Indian string instrument, the esraj. (Image credits: top, E O Hoppe/LIFE; below, Birla Industrial and Technological Museum.)

organization has also taken the lead in exploring for the long-term future the scientific, technological and fiscal limits of the highest energy scales achievable in laboratory based particle colliders, via the recently launched Future Circular Collider (FCC) design effort, to be completed by 2018. In this bold initiative, in line with its past tradition, CERN has again taken the progressive approach of basing such colliders on technological innovation, pushing the frontier of high-field superconducting dipole magnets beyond the 16 T range. The ambitious strategy inspires societal aspirations, and has the promise of returning commensurate value to global creativity and collaboration. It also leaves room for a luminous electron–positron collider as a Higgs factory at the energy frontier, either as an intermediate stage in the FCC itself or as a possibility elsewhere in the world, and is complementary to the development of emerging experimental opportunities with neutrino beams at the intensity frontier in North America and Asia.

What a marvellous pursuit it is to reach ever higher energies via brute-force particle colliders in an earth-based laboratory. Much of the physics at the energy frontier, however, is hidden in the so-called “dark sector” of the vacuum. Lucio Rossi wrote in this column last month how light is the most important means to see, helping us to bridge reality with the mind (*CERN Courier* March 2015 p54). Yet even

light could have a dark side and be invisible – “hidden-sector photons” could have a role to play in the world of dark matter, along with the likes of axions. And dark energy – is it real, what carries it?

All general considerations for the laboratory detection of dark matter and dark energy lead to the requirement of spectacular signal sensitivities with the discrimination of one part in 10^{25} , and an audacious ability to detect possible dark-energy “zero-point” fluctuation signals at the level of 10^{-15} g. Already today, the electrodynamics of microwave superconducting cavities offers a resonant selectivity of one part in 10^{22} in the dual “transmitter–receiver” mode. Vacuum, laser and particle/atomic beam techniques promise gravimeters at 10^{-12} g levels. Can we stretch our imagination to consider eavesdropping on the spontaneous disappearance of the “visible” into the “dark”, and back again? Or of sensing directly in a laboratory setting the zero-point fluctuations of the dark-energy density, complementing the increasingly precise refinement of the nonzero value of the cosmological constant via cosmological observations?

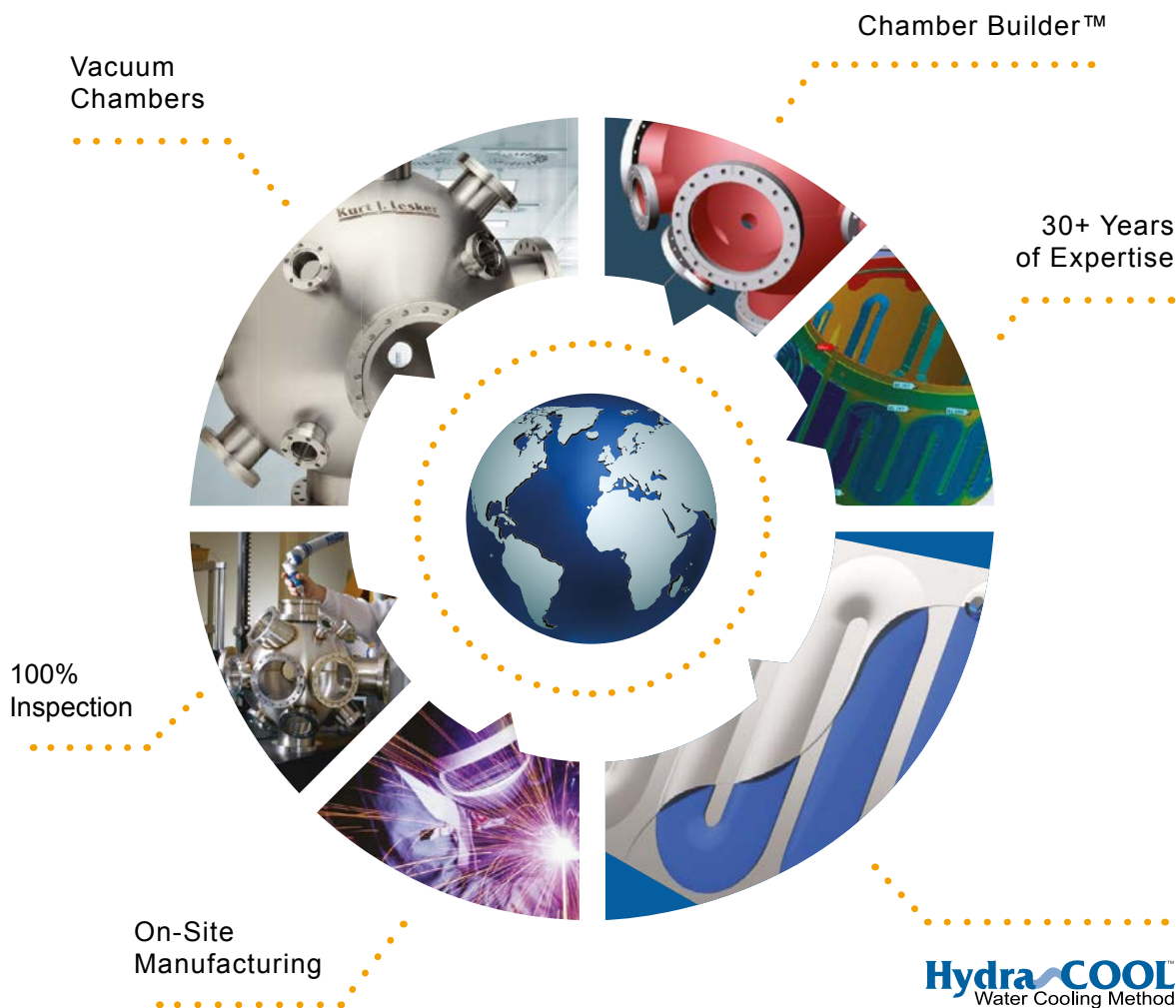
The comprehensive skills base in accelerator, detector and information technologies accumulated across decades at CERN and elsewhere could inspire non-traditional laboratory searches for the “hidden sector” of the vacuum at the cosmic frontier, complementing the traditional collider-based energy frontier.

Like the synergy between harmony and melody in music – as in the notes of the harmonic minor chord of Vivaldi’s *Four Seasons* played on the violin, and the same notes played melodiously in ascending and descending order in the universal Indian raga *Kirwani* (a favourite of Bose, played on the esraj) – the energy frontier and the cosmic frontier are tied together intimately in the echoes of the Big Bang, from the laboratory to outer space.



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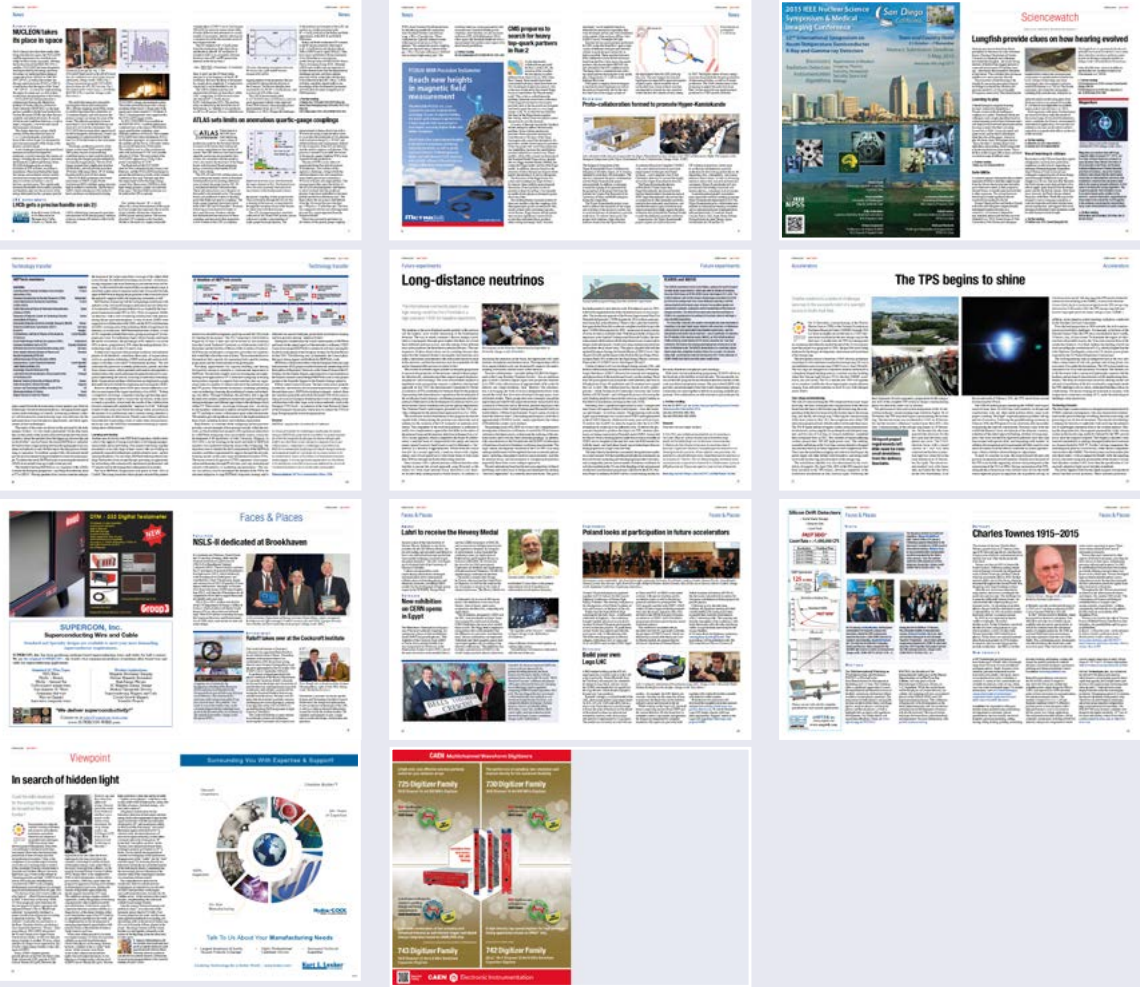
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WELCOME

CERN Courier – digital edition

Welcome to the digital edition of the April 2015 issue of *CERN Courier*.

Celebration of the International Year of Light and Light-based Technologies (IYL 2015) continues in this issue with a look at the challenges in building a new light source in South East Asia, while Viewpoint asks whether the skills developed for high-energy physics could be used to make the dark side of the universe visible. These skills are already being directed at a large-scale project to investigate further what are arguably the most invisible of the elementary particles – the neutrinos. Celebrations also extend to wishing a happy 90th birthday to *CERN Courier*'s first editor, Roger Anthoine.

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