Keeping particles on the straight and narrow

Ensuring particle accelerator beams stay aligned is difficult - but physicists from the University of Oxford have developed incredibly fast systems to keep them in check.

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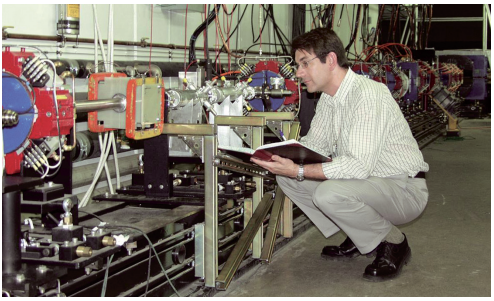

Things move fast in particle accelerator physics, in more ways than one. That is why physicists at the University of Oxford are already working on technologies that might be used in a follow-up to CERN's LHC: a new high-energy linear collider.

Researchers from the John Adams Institute for Accelerator Science, led by Prof. Philip Burrows, are working on a particularly crucial area: how to ensure that the colliding beams of particles actually hit each other. Natural ground vibrations disrupt the magnets used to keep electron beams on-track, causing the beams to become mis-aligned over time, so advanced feedback systems are required to track and correct the errant beams.

However, the designs for the proposed accelerators of the future present major technological challenges. One design, referred to as the International Linear Collider, produces bunches of electrons separated by just 300 nanoseconds - which is so quick that the existing technologies cannot adjust the beams in time. But University of Oxford physicists have managed to construct a digital system, clocked to run at 375 Ms/s, that can keep up. When the beam moves off-axis, the digital components can work quickly enough to calculate what needs to be done and implement the change before the next bunch arrives.

A competing design, the Compact Linear Collider, presents an even bigger problem. Its bunches of particles arrive every 0.5ns, in streams just 150ns long, leaving even the newest digital systems ineffectual. So the same team set out to build an ultra high-speed analogue system, capable of detecting changes and adjusting the beams trajectory. With the most exotic sensors, actuators and amplifiers, and years of collaborative R&D, they have been able to reduce the system's response time to just 13ns in experiments at the Accelerator Test Facility in Japan. They have also shown that they can shift the beam by up to 100 microns, with an accuracy of less than 1 micron – a performance level more than sufficient to accurately align beams in a collider.

Though the team's end goal is to see their technology in a new linear collider, their technology has many other potential applications, including future X-ray light sources and a possible 'SuperB Factory'. With over 25,000 particle accelerators across the world, though, their design looks set to become vital wherever rapid beam steering correction is required.

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