Space probe

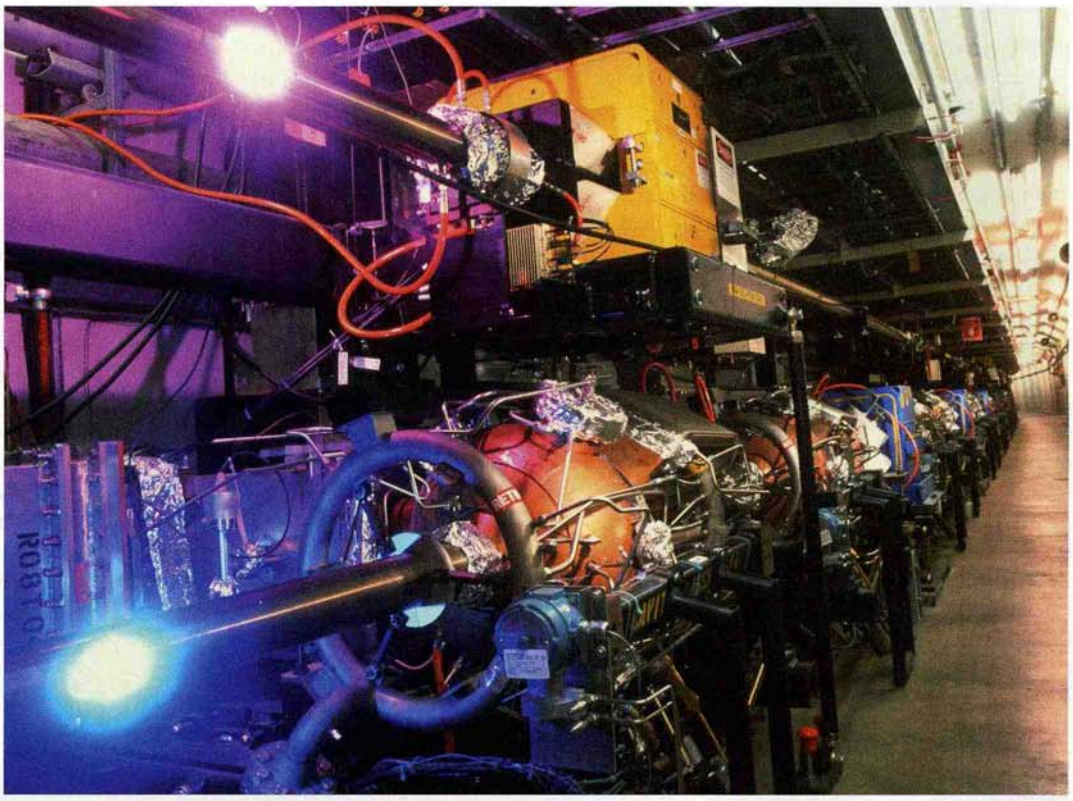
Oxford scientists help build parallel linear accelerators in search for secret of the universe's mass

A UK-DEVELOPED key component of the International Linear Collider (ILC) – one of science's most ambitious ever projects – has successfully completed prototype testing.

The proposed £4bn ILC facility would smash electrons and positrons together at the midpoint of a 32km tunnel at almost the speed of light, potentially revealing the Higgs boson, or so-called 'God particle' that gives mass to the rest of the universe.

Engineers at Oxford University and London-based TMD Technologies have developed a custom power amplifier that will 'kick' the beams back onto a collision course if they stray off target.

The amplifier, a prototype of which has just successfully completed testing in Japan, is a key component of an ultra-fast feedback system being developed at Oxford to control the beams.



Search: linear collider systems enable scientists to look for the mechanisms by which mass in the universe is generated

Feedback system

The feedback system will detect the positions of each of the 3,000 bunches of electrons and positrons that are fired five times every second.

Scientists will then use the first few bunches to calculate by how much the beams miss, then apply a correcting kick via the amplifier to steer the subsequent bunches into head-on collisions 14,000 times per second at extremely high energies – 500 billion electron volts (GeV).

Philip Burrows, leader of the Oxford team, said many factors could conspire against the beams colliding. One problem, he said, was that the huge collider facility was extremely noisy and ground motion caused by the sound could make the beams miss each other.

'In industrial facilities, things vibrate with 10μ of root m^2 random motion,' he said. 'At the ILC these beams will be roughly 5nm high, but the components are wobbling at micron level, so they are not going to hit one another unless we do something.'

In addition to mechanical noise, electrical noise can also cause random motion. To help control this, the amplifier is earthed by using multi-parallel output channels with the input stage isolated to prevent ground loops.

The feedback system works by detecting the location of electrons and positrons with a beam position monitor using an electromagnetic pickup.

The device is then able to position the beams by using advanced signal processing techniques. The position signal will then go into a digital processor that emits a correction signal to drive the amplifier.

After a delay of just 35 nanoseconds, the system will amplify the signal and pass it to the kicker, which can provide a ±70 amps output current kick to the electron beam and steer it where it needs to go.

Burrows said the 35ns delay time was critical to the entire process. 'At the ILC there will be between 3,000 and 6,000 bunches, and the time spacing between the bunches will be between 150ns and about 300ns,' he said.

'The total delay time must be shorter than the spaces in time between these bunches or else we will be too late. We will literally miss the beam.'

Another key feature of the amplifier is its method for reducing power consumption. The system de-powers the circuitry outside the pulse period by using a separate trigger input, which enables the amplifier before each pulse.

Size advantage

Perhaps one of the most practical features is its size. The amplifier measures about 15cm x 10cm, said Burrows. 'There isn't going to be a lot of space around with the real machine, and so it's a great advantage to have it small and compact,' he added.

Oxford is part of a coalition of 12 UK universities and laboratories that are working on different aspects of beam delivery for the ILC. More than 1,000 scientists from 100 countries are involved in the overall ILC project

The proposed location and timeframe for the ILC facility should be announced after 2010. 'If I were a betting man, the most promising site for the ILC, from the geopolitical view, is somewhere in the US,' Burrows said. 'The US needs a new big facility in particle physics if it wishes to continue to be a leader in the area.'

However, there are also proposals to build the ILC in Asia and Europe, while the huge cost of the project makes it uncertain that it will ever be built, despite the claims of scientists that it is needed to complement existing colliders.

The scientists point out that as well as revealing Higgs boson, the ILC could uncover new forms of matter and even extra dimensions of space.

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