NEWS AND ANALYSIS

New twist for next linear collider

Plans for an international linear collider could change dramatically if the Large Hadron Collider (LHC) at CERN in Geneva does not find evidence for the Higgs boson or supersymmetry. Most particle physicists agree that the next big machine after the LHC should be a linear electron-positron collider with an energy of 500–1000 GeV. However, it is becoming clear that CERN would prefer the linear collider to be based on CLIC, a novel design being developed at the lab that would generate collision energies of 3–5 TeV. Previously most particle physicists had assumed that CLIC would be more suitable for the next-but-one linear collider.

In January an International Technology Recommendation Panel (ITRP) started work on the task of deciding between two different approaches to a 500 GeV collider that could be upgraded to an energy of 1 TeV. Laboratories in the US and Japan are proposing to use conventional copper cavities to accelerate the particles in such a “sub-TeV” collider, while the DESY laboratory in Germany is working on a superconducting approach (see *Physics World* March pp8–10).

The ITRP is expected to announce its decision later this year, and, if all goes to plan, this decision will be followed by three more years of R&D and completion of an engineering design in 2010. If construction is approved in 2010, and the tricky issue of where to build the €4bn collider is resolved, the machine could be up and running by 2015.

Technology in waiting – in the end, the international linear collider may be based on CERN's CLIC design.

The feasibility of CLIC, on the other hand, has yet to be demonstrated, and such a machine could not start operating before about 2021. So why is CERN having second thoughts about a sub-TeV collider? “The actual decision to start construction of the linear collider will not be taken until 2010,” says CERN director general Robert Aymar. “By this time we will know much more about the best energy for a linear collider from the LHC and we will also know if CLIC is feasible for a 3–5 TeV collider. Any plan to build a linear collider has to be flexible enough to allow us to change our minds in 2010 in order to optimize the decision, according to necessities and possibilities.”

The status and funding prospects for a linear collider were discussed at an informal meeting in April attended by Aymar and

representatives of funding agencies from around the world. The meeting agreed that the “optimal strategy” would be to continue work on the sub-TeV collider, based on the technology chosen by the ITRP, and to produce a fully costed construction proposal in 2010.

But attendees also agreed that R&D should continue on CLIC, and that “physics criteria” for a linear collider should be defined before a decision to start construction can be taken. According to the minutes of the meeting, if the Higgs and supersymmetry are not found at the LHC, plans for a sub-TeV collider would be dropped and efforts would be focused on CLIC. The same group was due to meet again after *Physics World* went to press.

However, Brian Foster of Oxford University, chairman of the European Committee for Future Accelerators (ECFA), is convinced that a sub-TeV collider should be the next big machine in particle physics. “The ECFA report chaired by Lorenzo Foa unanimously agreed that a linear collider up to 1 TeV had a superb physics programme, independent of whatever the LHC may discover,” says Foster. “This report has been accepted by the European particle-physics community, and similar reports have been approved in US and Japan. I have seen nothing in the last two years to change my conviction that this is the correct next step for world particle physics.”

Peter Rodgers

RELATIVITY

Hawking loses wager on black holes

Stephen Hawking has changed his mind and admitted that information can escape from a black hole after all. The Cambridge theorist made his U-turn at a conference in Dublin last month when he revealed his solution to the “black-hole information paradox”. Hawking previously believed that all information that falls into a black hole is lost forever to the outside universe, even though this would mean a violation of the laws of quantum mechanics.

In announcing his change of heart, Hawking conceded that he had lost a bet about black holes that he and Caltech theorist Kip Thorne had made with John Preskill, also of Caltech, in 1997. Hawking and Thorne had argued that information is lost in a black hole, while Preskill said it was not and could, in principle, be recovered. Admitting defeat, Hawking honoured the terms of the bet and presented Preskill with a baseball encyclopedia “from which infor-

mation can be recovered with ease”. However, Thorne and other physicists remain unconvinced by Hawking's arguments.

The information paradox dates back to the 1970s, when Hawking – building on earlier work by Jacob Bekenstein – applied quantum theory to black holes. Classical physics says that black holes are regions of space where gravity is so strong that nothing, not even light, can escape from the “event horizon” that surrounds the hole. However, Hawking showed that these mysterious objects actually have a temperature, which means that they give off thermal radiation and should eventually disappear. The problem is that the radiation does not contain any information – so any information carried by light or matter that falls into the hole disappears. This is not allowed in quantum theory.

Hawking presented his solution to the paradox at the 17th International Confer-

ence on General Relativity and Gravitation. The solution relies on a black hole being able to have more than one topology at the same time. When Hawking performs a quantum-mechanical “path integral” over all the topologies, he finds that information is not lost. He argues that information can leave a black hole because a true “event horizon” never actually forms. “It is just an apparent horizon,” says Hawking, who also dismissed his previous suggestion that information could leak into a different “baby” universe.

But other physicists remain unconvinced by Hawking's arguments. “I must say that I am very disappointed with his ‘final explanation’,” says Gerhard 't Hooft of the University of Utrecht, who has spent almost 20 years trying to convince Hawking that information can leave a black hole. “The twist he seems to be adding to the story is that black holes are really never completely formed. This allows them to disappear again, and radiate back the quantum information that was – temporarily – absorbed. Many questions are left totally unanswered. We simply have to continue our research.”

Peter Rodgers and Martin Durrani