What's hanging on the Higgs

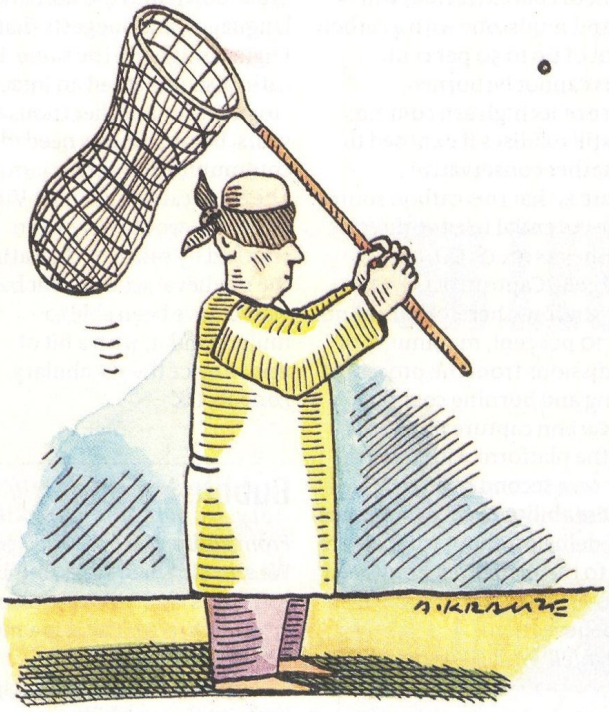
Finding the elusive Higgs particle will be fantastic. But not finding it could spell an even more exciting future for physics, says **Anil Ananthaswamy**

"THE goddam particle." That's what Nobel prizewinner Leon Lederman wanted to call the Higgs boson. In the end, his publisher's commercial instincts won out, and his book on the particle thought to endow the universe with its mass ended up with a rather more grandiose title: *The God Particle*.

It's a name that has caused considerable embarrassment to Peter Higgs, the physicist (and atheist) who postulated its existence – and by any reckoning the derogatory label might have been more appropriate, given the billions of dollars that have been spent chasing the elusive Higgs particle. Neverthless the name, combined with the breathless hunt, has helped the Higgs penetrate popular imagination. It was the subject of a novel by Herman Wouk, *A Hole in Texas*, which tells the tale of a physicist whose life unravels after the US government cancels the Superconducting Supercollider project (a real event) and derails the search for the Higgs.

The particle's iconic status goes a long way to explain the enthusiastic response that greeted Higgs himself last week when he visited the Large Hadron Collider (LHC), nearing completion at CERN, the European particle physics facility near Geneva in Switzerland. There he asserted that he is 90 per cent confident that the particle will be found by the LHC, which is expected to start smashing protons head-on sometime this year, and reach its full energy of 14 teraelectronvolts by mid-2009.

Higgs's confidence stems from the fact that the particle's existence is central to the standard model, which explains all known particles and the forces that act upon them. Until the early 1960s, the standard model was missing some glue: nothing in the theory showed why each of the particles has the mass it does. Then, almost simultaneously, Higgs at the University of Edinburgh in the UK and Robert Brout and François Englert of the Free University of Brussels (ULB) in Belgium realised that if the universe



was pervaded by something called a scalar field, it could explain how particles acquired mass. Higgs then pointed out that this field should itself be mediated by a particle.

Despite universal confidence in the Brout-Englert-Higgs mechanism, it is not clear that there is a single particle behind it. No signs of a lone Higgs particle have been detected in previous experiments at the Large Electron Positron collider at CERN, and at the Tevatron, Fermilab's particle accelerator at Batavia, Illinois.

There are even hints that all searches for the standard model Higgs might come up empty-handed. That's because two different ways of determining the mass range of the Higgs – if it exists – come up with different answers. The first is based solely on theoretical calculations using the standard model. The second is derived from the fact that the standard model tightly links the mass of the Higgs to the masses of the W boson, which carries the weak nuclear force, and the top quark, one of the fundamental constituents of matter – masses that have now been measured experimentally. The two predictions for the mass of the Higgs don't match, so something seems to be wrong.

"Finding signs of supersymmetry would give the first experimental backing for exotic new theories"

One fascinating possibility is that it could be the standard model that is at fault. That would be a dramatic turn of events for physics. The standard model has held its own against experimental onslaughts for decades. Failing to find the Higgs in the mass range where it is supposed to be would lift the lid on a whole world of physics beyond the standard model.

What could the alternatives be? The best bet is on a class of so-called supersymmetric theories. This as-yet unconfirmed view of the universe says that every particle in the standard model has a heavier partner particle. There are compelling theoretical reasons why supersymmetry might be correct. Supersymmetry predicts that multiple Higgs particles exist, the lightest of which is well within the LHC's range.

Physicists at the LHC are hedging their bets. As well as looking for the standard model Higgs, they will be sifting through the debris of proton-proton collisions for supersymmetric Higgs particles. So even if the Higgs remains elusive, particle physicists will be celebrating if the LHC finds signs of supersymmetry, as it would give the first backing for exotic theories such as string theory that up till now have had little if any experimental support.

If supersymmetry shows up, there will be a whole new set of particles to find, and there will be a stronger case than ever for building the next generation accelerator – the International Linear Collider (ILC). Of late, funding for the ILC has been evaporating fast. The UK pulled the plug in January, and the US has cut its funding by 75 per cent for this year.

The ILC's proponents will be happy to note that Higgs himself thinks there is about a 50 per cent chance that the LHC will find evidence of supersymmetry. The scenario that physicists hardly dare contemplate is that the LHC finds neither a standard model Higgs nor a whiff of supersymmetry. Then there will be little to show for the billions of dollars of investment – and the physicists who promoted it will have a lot of explaining to do.