LHC 2.0

A new view of the Universe

The LHC is a 27-kilometre ring that circulates beams of protons accelerated to near the speed of light in opposite directions. At four points, the two beams collide, creating showers of particles that are analysed by four detectors: CMS, ATLAS, ALICE and LHCb.

The world's most powerful particle collider is poised to roar once again into action after a two-year hiatus. At the end of March, the Large Hadron Collider (LHC) at CERN, Europe's particle-physics lab near Geneva, Switzerland, will start smashing particles together at a faster rate and with higher energies than ever before. "We're standing on the threshold of a completely new view of the Universe," says Tara Shears, a particle physicist at the University of Liverpool, UK.

The first run began in earnest in November 2009 and ended in February 2013. The LHC collided particles — mainly protons but also heavier particles such as lead ions — at high enough energies to discover the Higgs boson in 2012, which garnered those who predicted the subatomic particle a Nobel prize.

In the next run, set to last three years, energies will rise to an eventual 14 teraelectronvolts (TeV; see 'Hardware rebooted'). One hope is that higher energies will produce evidence for supersymmetry, an elegant theory that could extend the standard model of particle physics (see 'Desperately seeking SUSY'). They could also shake out particles of dark matter, the invisible substance that is thought to make up 85% of the matter in the Universe (see 'Decays decoded').

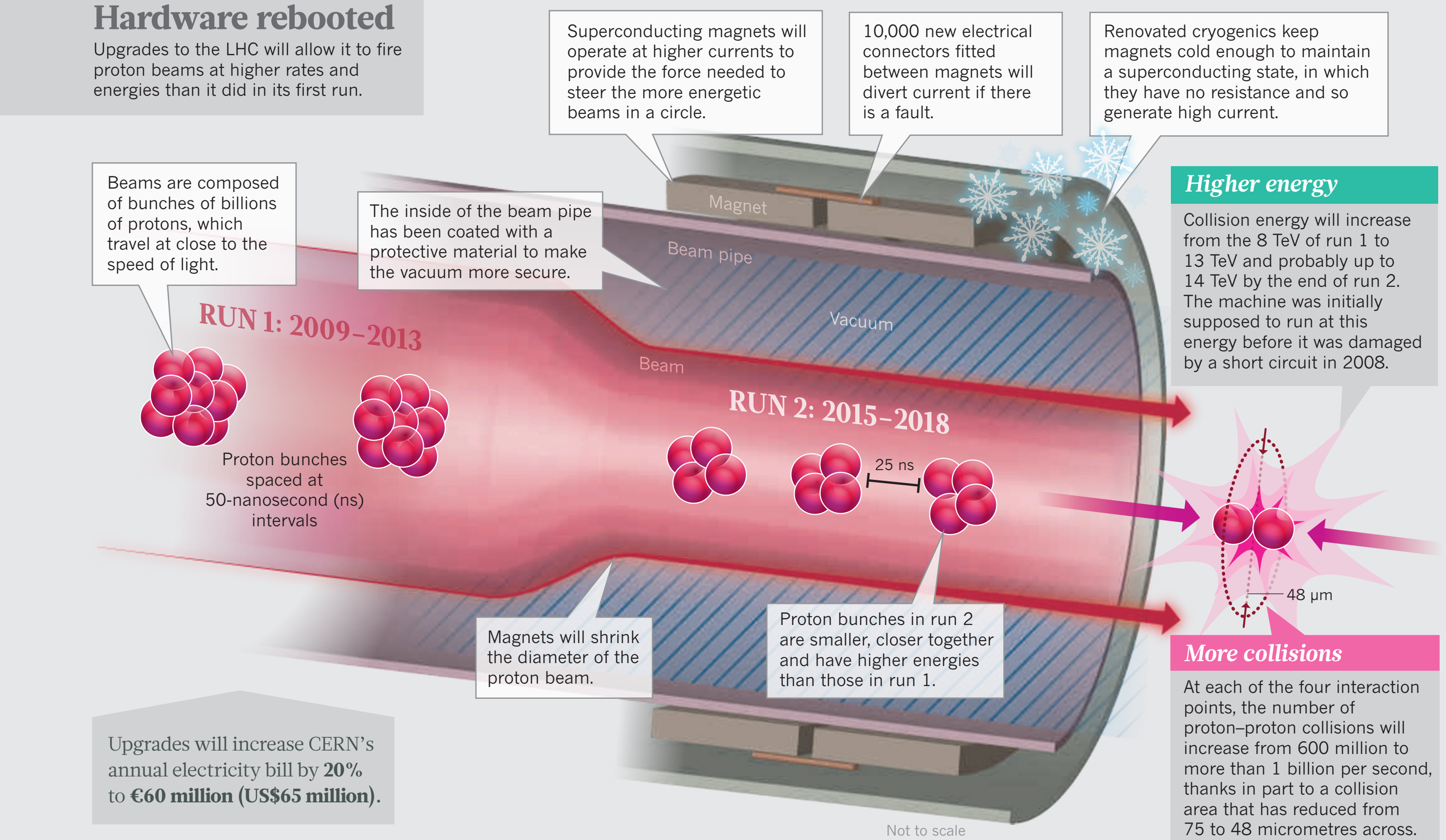
More collisions will enable more-precise study of the Higgs' nature (see 'The Higgs factory') and will provide clarity on anomalies hinted at in run 1 (see 'Known unknowns').

"In the first run we had a very strong theoretical steer to look for the Higgs boson," says Shears. "This time we don't have any signposts that are quite so clear."

BY ELIZABETH GIBNEY / ILLUSTRATION BY NIK SPENCER

Hardware rebooted

Upgrades to the LHC will allow it to fire proton beams at higher rates and energies than it did in its first run.

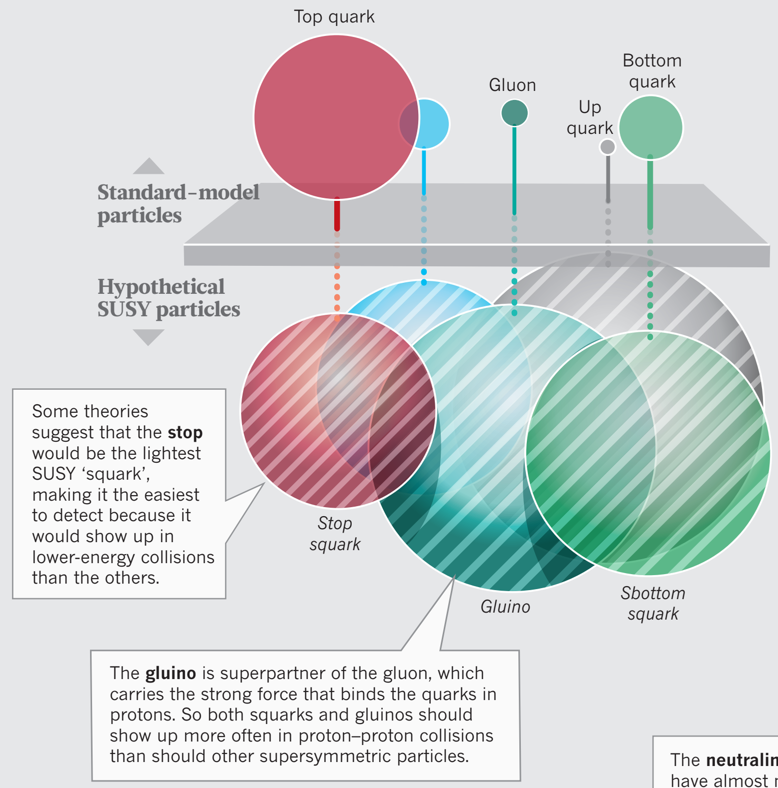


Upgrades will increase CERN's annual electricity bill by **20%** to **€60 million (US$65 million).**

Higher energy

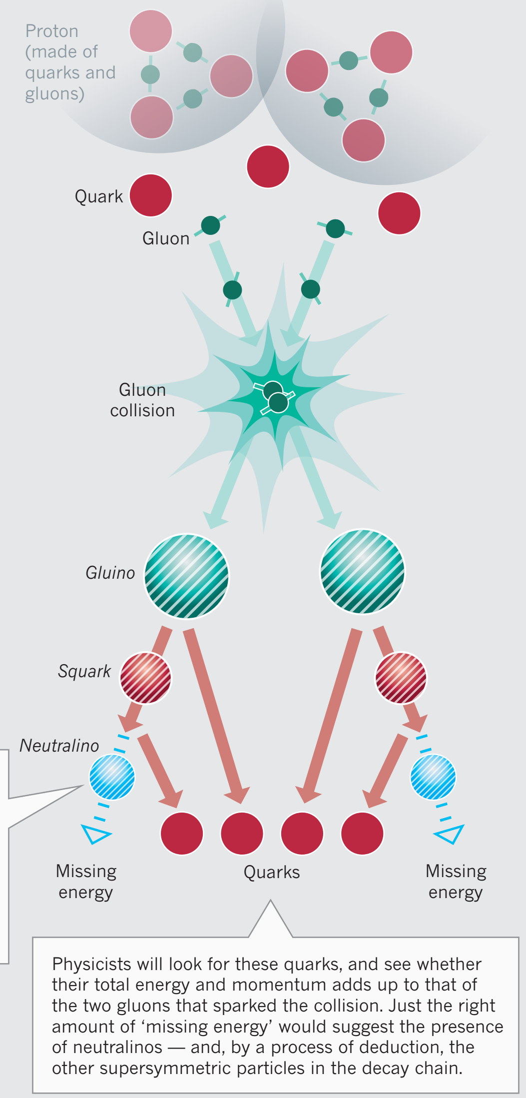
Desperately seeking SUSY

Higher energies mean that the LHC can produce heavier particles (because of $E = mc^2$) — and perhaps some of those predicted by the theory of supersymmetry, or SUSY. An extension to the standard model of particle physics, SUSY postulates a giant 'superpartner' for each known particle, and would offer explanations for mysteries such as the nature of dark matter.



Decays decoded

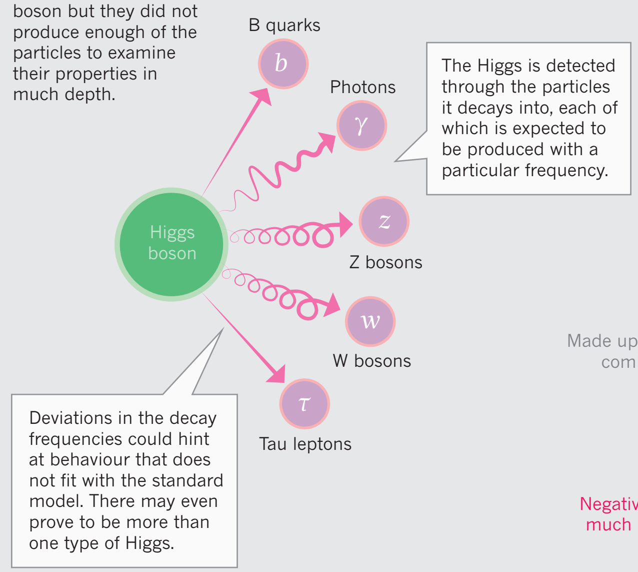
If the LHC makes supersymmetric particles, their lifetimes will be fleeting. But physicists can deduce their presence from the more-stable decay products. In at least one case, such SUSY clues could also be evidence for dark matter.



More collisions

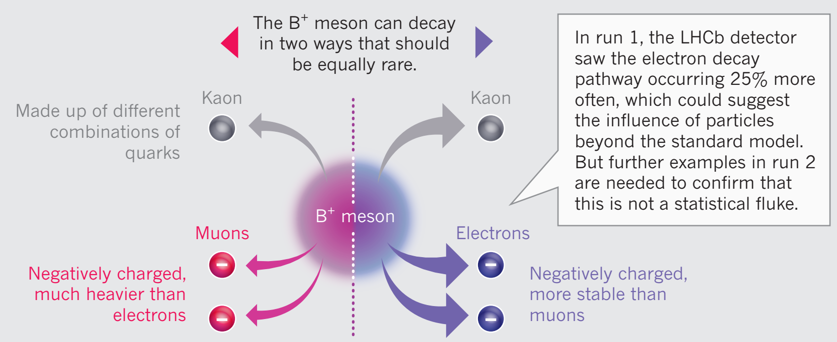
The Higgs factory

LHC experiments discovered the Higgs boson but they did not produce enough of the particles to examine their properties in much depth.



Known unknowns

More collisions will help to resolve some ongoing mysteries. One of these concerns an anomaly in the way a transient particle called a B^+ meson decays.



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