the classical value. There are formidable experimental challenges in attaining the required sub-microkelvin temperatures and extracting clear signals from the tiny atomic clouds, but the basic idea is stunningly simple.

Trusting quantum mechanics, one can then also convert the observed level of fluctuations into a temperature measurement. The results indeed agree with an independent, more classical thermometer based on measuring the momentum distribution in the gas. Now one big hope for the future is that, with the two methods calibrated against each other, the fluctuation-based thermometry can be extended to even lower temperatures where the momentum method is not sufficiently sensitive.

The present experiments[1,2] dealt with almost ideal, weakly interacting Fermi gases. This is a perfect setting for showcasing the fundamental principles of quantum mechanics in a beautifully clean fashion. However, even more exciting is the prospect of applying similar techniques to more complex, strongly interacting Fermi gases. In those systems, many issues involving thermometry and particle correlations are yet to be settled, and density fluctuations could very well provide an invaluable tool for discovering and understanding new physics. ❐

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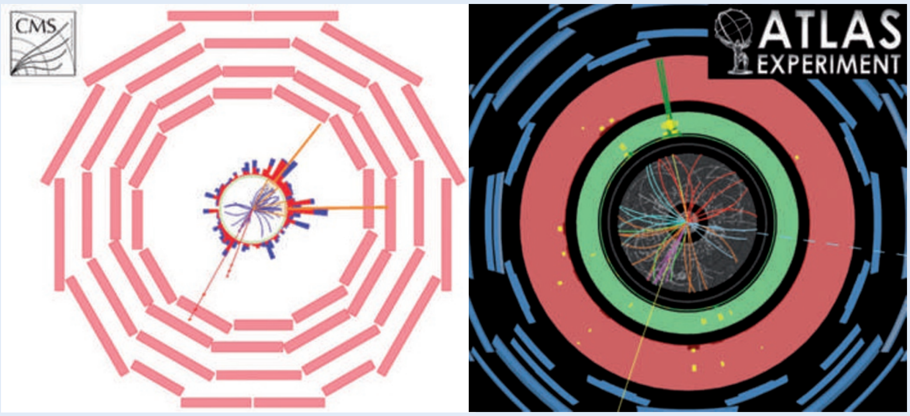
HIGH-ENERGY PHYSICS

Top of the class



CERN

The Large Hadron Collider has been in operation at CERN since the end of March this year, and all is going well. The machine's record-breaking performance, as it collides 3.5-TeV beams of protons, is being matched by the excellent response of the four detectors placed around the collider's 27-km ring. In particular, at the International Conference on High Energy Physics held in Paris, France, at the end of July (www.ichep2010.fr), the collaborations of physicists exploiting the two general-purpose detectors, ATLAS and CMS, were able to report their first probable sightings of top quarks.

Although long thought to complete the line-up of standard-model particles, the existence of the top quark was confirmed by experiment only in 1995, at Fermilab's Tevatron in the USA. The handful of candidate events from ATLAS and CMS are the first direct evidence of top quarks to be gathered in Europe.

Top quarks can be produced in pairs — a top quark and an anti-top quark — in proton collisions of sufficient energy. Each is short-lived and can decay into a *W* boson and another quark, the partner of the top, called 'bottom'. These are also short-lived, the bottom quark creating a spray of other particles known as a jet and the *W* boson producing either two jets, or a lepton (electron, muon or tau) and a neutrino. This 'debris' leaves distinctive signatures in the ATLAS and CMS detectors.

In the events displayed here, CMS has captured two bottom-quark jets, two muons (red tracks) and registered an energy imbalance in the interaction — missing energy is likely to have been carried off by two undetectable neutrinos; ATLAS has picked up four jets, a single electron (yellow track pointing to a green cluster) and also recorded missing transverse energy (blue dashed line) owing to the escape of a neutrino. Both events match the expected signature of top-quark production.

It's still early days for the LHC experiments (including the two more specialized detectors, LHCb and ALICE), as they 'rediscover' the standard model — checking, calibrating and proving the performance of their systems using the well-understood physics of the known quarks and leptons and of the *W* and *Z* bosons. As data accumulate, the hunt will be on for the unusual: supersymmetric particles are the favourites for an early discovery, possibly in the next year.

But the hunt isn't over yet at Fermilab's Tevatron. In Paris, the Tevatron collaborations, CDF and DØ, presented the outcome of their latest search for the standard-model Higgs boson: its existence is now excluded, at 95% confidence level, in the mass range 158–175 GeV. However, a hint of new physics has emerged in a specific analysis by DØ of particles containing bottom quarks (http://arxiv.org/abs/1007.0395). It seems these '*B* mesons' may be subject to a greater level of so-called CP violation than is expected, according to the standard model of particle physics. At present, the significance of the result stands at 3.2σ — tantalizing, but not yet conclusive. Although the Tevatron has been scheduled to shut down for good in 2011, some physicists are now pushing for it to continue running for two or three years more.

ALISON WRIGHT