The big time

Two big-science projects — the Large Hadron Collider and the Planck satellite — are set to deliver major results in the coming year.

There may be Olympic Games and a US presidential election to look forward to, but 2012 is also the year in which some truly memorable science could happen. Both the Large Hadron Collider (LHC) at CERN and the European Space Agency's Planck satellite are on the threshold of potentially major discoveries, or at least significant progress, in fundamental physics — the LHC as it continues the search for conclusive evidence of the Higgs boson and Planck as it maps the cosmic microwave background (CMB) in greater detail than ever before.

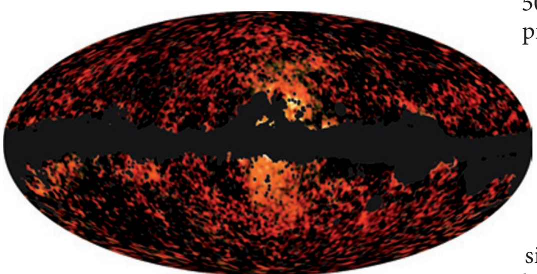
Following its launch in May 2009, the Planck satellite moved into orbit around the second Lagrange point, about 1.5 million kilometres from Earth. It was intended to operate for 15 months and perform two surveys of the full sky. In November 2011, the coolant serving its High Frequency Instrument, which is so acutely sensitive to the CMB, ran out. The mission was at an end — but a full 30 months and five full-sky surveys later.

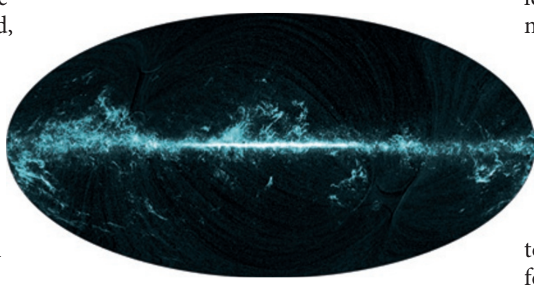
Some data have already been released by the Planck collaboration — notably in January 2011 its 'early release compact source catalogue' of thousands of very cold sources across the sky, seen at millimetre and submillimetre wavelengths. Last month, more data followed, including a remarkable map of the so-called galactic haze (pictured, top). This microwave radiation emanating from a region around the galactic centre is thought to be synchrotron emission, but has a curiously harder spectrum than the synchrotron emission seen elsewhere in the Milky Way. As yet it remains unexplained, but supernovae, galactic winds and even dark matter are on the list of suspects.

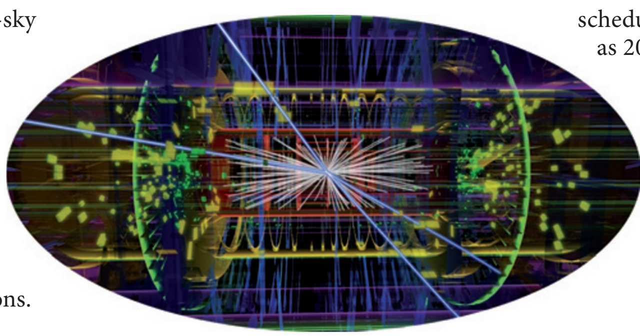
Planck has also traced the first all-sky map of carbon monoxide (pictured, middle). Carbon monoxide forms in cold clouds of gas, which are mostly hydrogen and from which stars are created. Hydrogen molecules are poor emitters, however — unlike carbon monoxide molecules, which, although less abundant, are much more easily detected and hence are useful signifiers of star-forming regions.

Both of these maps are only part of the bigger picture, however, for the Planck collaboration. They are now embroiled in understanding and carefully substracting all sources of foreground emission — including carbon monoxide and the galactic haze — from their data, to reveal the prize: a map of the CMB radiation in even greater detail than was drawn by the satellite's predecessor, NASA's Wilkinson Microwave Anisotropy Probe. That detail is crucial if the data are to provide significant clues to the inflationary history of the Universe and the existence of primordial gravitational waves. By the end of the year, a substantial part of the work should be done, and a map based on roughly half of Planck's data is expected to be released in early 2013. The full data release will follow in 2014.

The end of 2011 also marked a milestone in operation of the LHC. The collaborations working with the LHC's two general-purpose detectors, ATLAS and CMS, presented tentative evidence in the data taken so far of something potentially Higgs-like, with a mass in the 125 GeV region (including this four-muon signature collected by ATLAS, pictured bottom). Data taken in 2012 should rule conclusively on whether the hint is real, or not — and at the annual LHC performance workshop, held last month in Chamonix, France, plans were laid accordingly.







BOTTOM: © CERN/ATLAS; MIDDLE AND TOP: © ESA/PLANCK COLLABORATION

First came a careful appraisal of the accelerator's performance in 2011, to understand and solve issues such as vacuum spikes and heating due to the high intensity of the colliding proton beams. An operational success in 2011 was the 'squeeze' — reducing the size of the proton beams at the interaction points around the ring, to improve the rate of collisions. Squeezing harder in 2012, with tighter collimator settings, could push the peak luminosity more than 50% higher. Although the spacing of the proton bunches within the beams will remain the same, at 50 ns, the beam energy will be pushed up from its 2011 value of 3.5 TeV, to 4 TeV for 2012. All told, the machine is on target to deliver 15 inverse femtobarns of data to the waiting experiments — sufficient to confirm the putative Higgs signature, or to exclude at 95% confidence level the very existence of a standard-model Higgs.

For particle physicists, to be now so close to such a definitive statement on the Higgs boson is beyond exciting. Should there be any delays or setbacks, however, the possibility of extending the 2012 data-taking run of the collider has not been ruled out, to be sure of accumulating those 15 inverse femtobarns before the machine's first scheduled 'long shutdown'. For as many as 20 months, through 2013 and into late 2014, the LHC will be switched off to allow a programme of maintenance and improvement that should enable a restart at even higher energy — 6.5 TeV per beam, before the push up to the design energy of 7 TeV.

For Planck and the LHC, this time, it is the big time. ❐