Moving Closer to the Higgs Boson Mass

The CDF and DZero experimental collaborations at Fermilab have pooled data from their independent studies of high-energy proton-antiproton collisions at the Tevatron, currently the world's most powerful accelerator, in the ongoing search for the elusive Higgs boson.

"The two experiments have similar coverage, although probably they have better calorimetry and we have better tracking," says Lina Galtieri, who heads the Berkeley Lab CDF group, a collaboration of 602 physicists from 15 countries. "In searching for the Higgs, everything is needed – every piece of information that comes from the detector is valuable."

"Usually the two teams are friendly competitors," says Wei-Ming Yao of Berkeley Lab's Physics Division, a member of the CDF experiment who is been involved in the data analysis. "But to find something interesting about the Higgs we knew we needed to work together."

In this way the teams have effectively doubled the amount of data in their search. The result is that they have established that the Higgs will almost certainly not be found – the chances are less than one in 20 – lying within the mass/energy range between 160 and 170 GeV/c^2. (Because mass and energy are equivalent, as expressed by $E=mc^2$, particle masses are written as their energy in electron volts, divided by the speed of light squared; the speed-of-light term is often omitted for convenience).

Earlier results from CERN's Large Electron-Positron Collider established that the Higgs must "weigh" more than 114 GeV, and theoretical calculations supported by observation indicate the Higgs must weigh less than 185 GeV. Thus the mass/energy range excluded by the new analysis takes a big bite out of the upper end of the search area.

The Large Hadron Collider (LHC) at CERN, headquartered in Geneva, Switzerland, also intends to find the Higgs, which is the last of the fundamental particles predicted in the Standard Model of Particles and Interactions that remains unseen. Although the LHC produced its first beams last September 10, it had to be shut down in late September and is now undergoing repairs. Beams are again expected this fall, with the LHC's first collisions anticipated in late October.

The new constraints on the likely mass of the Higgs change how it will be seen and raise the possibility that it could be found at Fermilab.

"At low mass the Higgs involves finding b-bbar pairs," Galtieri explains. Here b is the bottom quark and bbar the antibottom quark. The two are also produced in pairs from other processes, with the more likely route for a higher mass Higgs to decay via two W bosons. "In the lower mass region there is a lot of background from other events," she says.

"And in this low mass region, it may be more difficult for the LHC," Yao says. "It will have to run longer to sort through all the data. With our improved analytic methods, and the doubling of the dataset, the Tevatron has a better than one-in-three chance to find it, and we keep getting better. The Tevatron is running marvelously. But by the end of 2010, the LHC will have accumulated enough data to make the discovery that may change the world."

"The physics world, that is," Galtieri specifies. "It may take a while for a fundamental discovery like the mass of the Higgs boson to affect the man on the street, but it will."

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