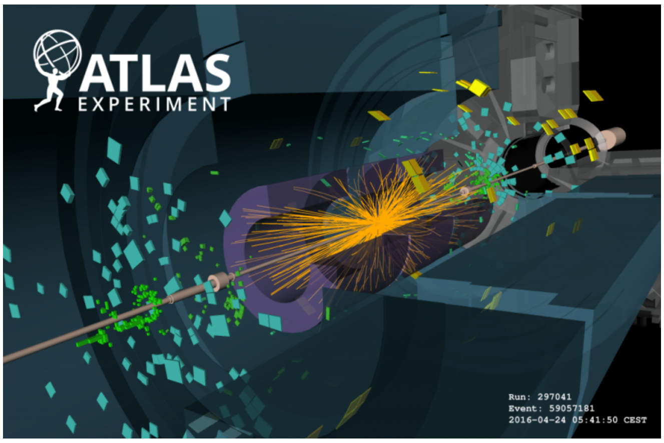
LHC reboot promises piles of new data

17 May 2016, by Kara Manke



CERN's Large Hadron Collider (LHC) creates exotic forms of matter by smashing together protons that are traveling at nearly the speed of light. This image depicts a collision detected by the LHC's ATLAS Experiment, which Duke physicists collaborate on, during beam commissioning in April. Credit: CERN

Undeterred by a recent weasel incursion, CERN announced last week that the Large Hadron Collider (LHC) is back up and running for the 2016 season, smashing protons together at nearly the speed of light and creating exotic forms of matter in the debris.

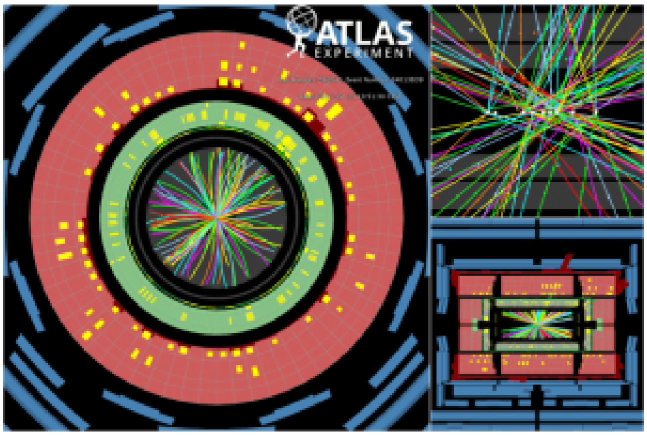
Back at Duke, students and professors collaborating on LHC's ATLAS experiment are eager to see if the 2016 run provides any hint of surprising new physics.

"It's a really exciting time," said Duke graduate student Douglas Davis. "Hopefully something comes out of this new data that we aren't expecting."

Since the early 1970s, physicists have relied on the Standard Model of physics to explain all the most basic bits of matter in the universe and the forces through which they interact. And it has performed remarkably well at describing all of the curious new particles the LHC has created, from the magnificent Higgs Boson to that quirky pentaquark spotted last year.

But the Standard Model can't quite explain everything. For instance, it cannot reconcile gravity – the force whose existence we verify every time we knock over a coffee mug or drop a pen – or dark matter, which physicists know exists from observations of twisted galaxies in the cosmos.

During the upcoming run, the Large Hadron Collider will be operating at its full design capacity, smashing proton bunches at energies of 13 TeV (trillion electron-volts), which is almost twice the collision energy it was capable of during the 2009 to 2013 "Run 1" that discovered the Higgs.



A view of the proton collision debris field looking down the beam line (left) and from the side of the beam line (bottom right). On the top right, a zoomed-in view of the proton interaction region, showing the locations where they collide (white squares) and the reconstructed tracks. Credit: CERN

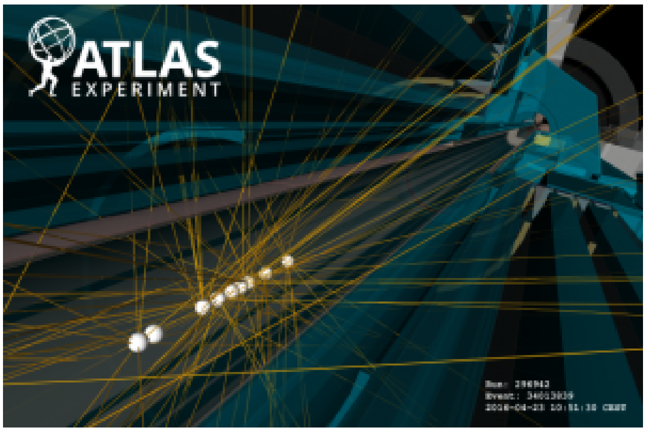
For the 2016 re-boot, they have also increased the "luminosity" of the beams, narrowing the size of the proton bunches to boost the number of collisions per pass by five or six times – resulting in five to six times more data.

To a particle physicist, more energy and more data means a better chance of finding anomalies in the Standard Model that could lend credence to alternate theories, like supersymmetry or string theory, or point in an entirely new direction all together.

"Anything that is even a hint of something new or non-expected these days gets everyone abuzz." said Davis. "Everyone is waiting on pins and needles for something to happen."

Most of the excitement in the physics world is currently over a "bump" at 750 GeV observed during the 2015 run. If confirmed, this signal could mean the discovery of a completely new particle that is six times heavier than the Higgs. But, it could also just be a statistical fluctuation.

"There is a huge amount of excitement now because soon after start-up in a few months, we should be able to determine whether that bump is real or not," said physics Professor Mark Kruse, who leads Duke's ATLAS team. "I'm right on the fence for whether it could be real or not real, but would probably bet that it's not. It certainly doesn't belong to the standard model, but unfortunately it also doesn't fit very nicely into any of the favored contenders to replace the standard model."



One of the early proton-proton collisions with recorded by ATLAS on 23 April 2016. The picture shows the very inner core of the ATLAS detector where the two beams of proton bunches from the LHC collide . In this event the colliding protons give birth to ten primary interactions, shown in white. The reconstructed tracks of the particles produced in those interactions are drawn in yellow. Credit: CERN

The Duke team won't be focusing all its energy there. Kruse says they have researchers working on a wide variety of projects, from searching for new dark matter candidates to closely analyzing rare Standard Model events.

Davis plans to employ an analysis technique called AIDA, originally developed by Kruse, his advisor, and Kruse's first graduate student, Sebastian Carron. Davis will use the technique to search for anomalies in a rare Standard Model process that produces two top quarks along with a Z or W boson.

And even if everything works out just as the Standard Model predicts, Davis still thinks the fact that we can collect this data at all is still pretty impressive.

"It may seem kind of boring to see everything work exactly as the Standard Model says it should, but at the same time it's like – man, this was written down in the seventies and they probably would never have dreamed of being able to observe all this," said Davis. "But so far, it works perfectly."

Provided by Duke University