ENERGY

Units 10,11 , Dr. John P. Cise, Professor of Physics, Austin Com. College, Austin Texas USA , jpcise@austincc.edu , & NYTimes , December 25, 2019 by Dennis Overbye

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"A SMASHING INTERMISSION"

INTRODUCTION: Goal here is to verify proton moving at stated speed of v = 0.99 999 99 c(c = speed of light = 3.0 X 10^8 m./s.) { actually according to LHC site v = 0.99 999 9991 c} has 7 X 10^{12} ev (electron volts) of energy, 7 trillion electron volts of energy as stated in articl here. According to Einstein $E = m c^2$ where m = $m_o/(1 - v^2/c^2)$, m_o = rest mass energy of Proton = 1.673 X 10^{-27} kg.. We will use here the ACTUAL LHC stated speed v = 0.99 999 9991 c.

QUESTIONS: (a) Find energy of proton moving at v = 0.99 999 9991 c in units of Joules., (b) Find energy of proton moving at v = 0.99 999 9991 c in electron volts(ev)?, (c) The article states the protons make 11,000 loops of the 17 mile long LHC circumference in 0ne second. Show this is close to speed of light? (d) Verify the last article statement: E_{PROTON} = $Mass_{PROTON}$ = ~ 10^9 EV ?

MEYRIN, Switzerland — There is silence on the subatomic firing range.

A quarter-century ago, the physicists of CERN, the European Center for Nuclear Research, bet their careers and their political capital on the biggest and most expensive science experiment ever built**, the Large Hadron Collider.**

The collider is a kind of microscope that works by flinging subatomic particles around a 17-mile electromagnetic racetrack beneath the French-Swiss countryside, smashing them together 600 million times a second and sifting through the debris for new particles and forces of nature. The instrument is also a time machine, providing a glimpse of the physics that prevailed in the early moments of the universe and laid the foundation for the cosmos as we see it today. **The reward came in 2012 with the discovery of the Higgs boson, a long-sought particle that helps explain why there is mass, diversity and life in the cosmos.** The discovery was celebrated with champagne and a Nobel prize. The collider will continue smashing particles and expectations for another 20 years.

But first, an intermission. On December 3rd, the particle beams stopped humming. The giant magnets that guide the whizzing protons sighed and released their grip. The underground detectors that ring the tunnel stood down from their watch.

Over the next two years, during the first of what will be a series of shutdowns, engineers will upgrade the collider to make its beams more intense and its instruments more sensitive and discerning. And theoretical physicists will pause to make sense of the tantalizing, bewildering mysteries that the Large Hadron Collider has generated so far. **The collider gets its mojo from Einstein's dictum that mass and energy are the same.** The more energy that the collider can produce, the more massive are the particles back in time, closer to the physics of the Big Bang, when the universe was much hotter than today. Inside CERN's subterranean ring, some 10,000 superconducting electromagnets, powered by a small city's worth of electricity, guide two beams of protons in opposite directions **around the tunnel at 99.99999 percent of the speed of light, or an energy of 7 trillion electron volts.** Those **protons make the 17-mile circuit 11,000 times a second**. (In physics, mass and energy are both expressed in terms of units called electron volts. A single proton, the building block of ordinary atoms, weighs about a billion electron volts.

HINTS: 1.602 X 10^{-19} J/ev, 1609.344 meters/mile., A single proton at rest has a energy of E = $m_o c^2$, m_o (proton) = 1.673 X 10^{-27}

ANSWERS: (a) 1.12228 X 10^{-6} J, (b) 7 X 10^{12} ev, (just as the article stated for a proton moving at v = 0.99 999 9991 c, (c) v = close to just under c = 3 X 10^8 m./s., (d) proton weight in ev = ~ 0.939 X 10^9 ev