Energy and momentum units in particle physics

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Use of 'GeV-type' units rather than SI in Particle Physics

In ordinary Newtonian physics, given the **kinetic energy** $\boldsymbol{E_k}$ of a particle (4 Joules, say) and its **momentum** $\boldsymbol{p}$ (4 kg m/s), one can calculate

$$m = p^2/2E_k = 2\ \text{kg}$$

In highly relativistic collisions at the LHC, the **total energy** $\boldsymbol{E}$ of a particle is measured by detectors quaintly called 'calorimeters', and the **momentum** $\boldsymbol{p}$ by determining the curvature of charged tracks moving in a magnetic field.

Then, using $E^2 = p^2c^2 + m^2c^4$, we can calculate the mass m:

$$m = \sqrt{\frac{E^2 - p^2c^2}{c^4}}$$

Given ***E*** in Joules, ***p*** in kg m/s, and ***c*** = 3 x 10^8 m/s, this yields ***m*** in kg.

However:

Particle physicists measure energies in GeV, where
1 GeV = 10^9 eV = energy gained by an electron or proton accelerated through 10^9 volts.

How does one use $E^2 = p^2c^2 + m^2c^4$ to measure mass using particle physicists' units?

For the units in each term of $E^2 = p^2c^2 + m^2c^4$ to be the same,

p must be in GeV/c and *m* must be in GeV/c^2.

Then E^2 (in GeV^2) = p^2 (in GeV^2/c^2) c^2 + m^2 (in GeV^2/c^4) c^4

Physicists 'simplify' this by writing it as
E^2 (in GeV^2) = p^2 (in GeV^2) + m^2 (in GeV^2)

So when you see $E^2 = p^2 + m^2$ think of

What is a highly relativistic particle?

$$E^2 = p^2c^2 + m^2c^4$$

$p^2c^2 \gg m^2c^4 \Longrightarrow E \sim pc$

* Examples/discussion