

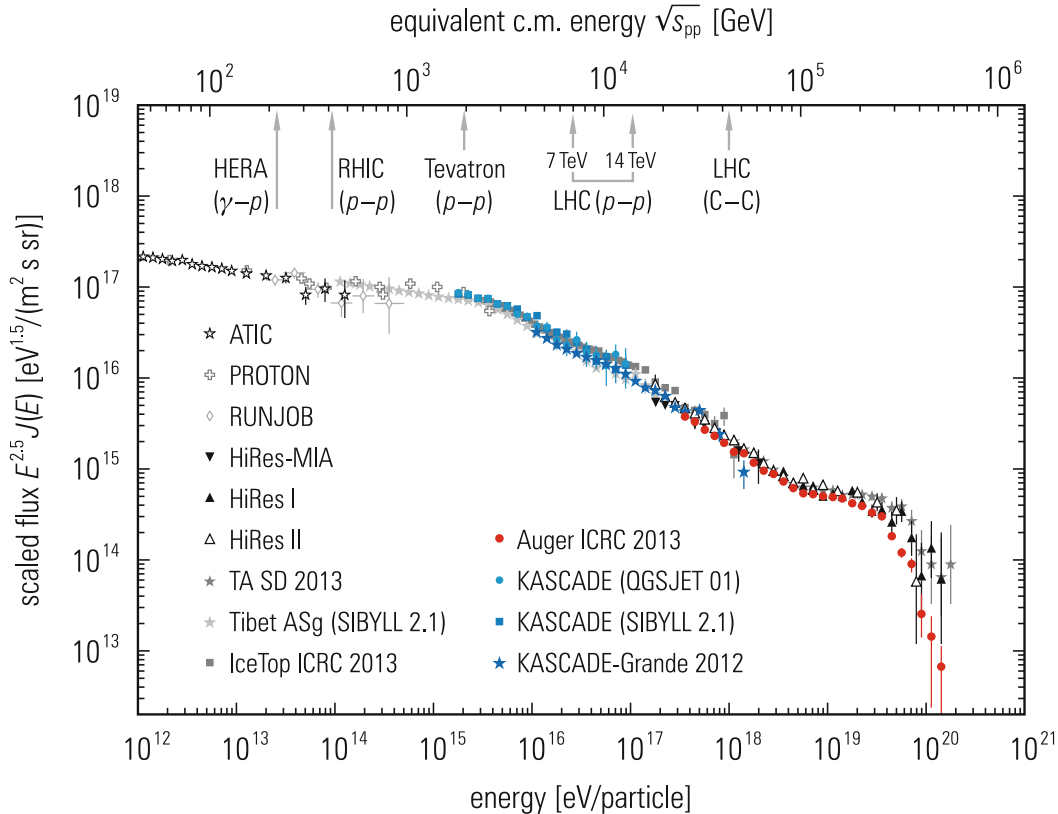
Introduction to astroparticle physics

Part 2, Exercises 1

April 11, 2025

1 Equivalent center-of-mass energy

Find the center-of-mass energy of a cosmic proton with energy $E_1 = 10^{17}$ eV impinging on a proton at rest.



2 Maximum proton energy at LHC

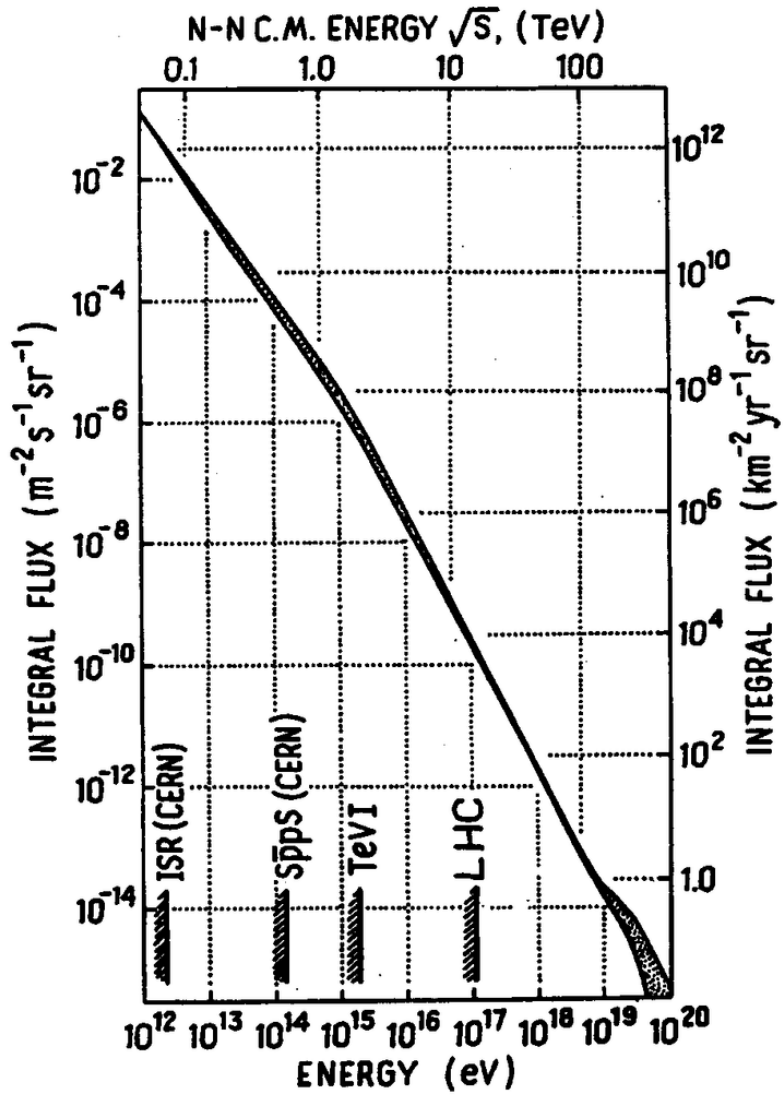
Calculate the maximum energy attainable by protons in a tunnel with a circumference of 27 km and a magnetic field of 8.36 T.

3 Differential energy flux of protons

Relativistic cosmic protons are accelerated by a shock front. Deduce the form of the differential energy flux of the protons, assuming that the probability that the proton escapes the acceleration process is 20% and the fractional increase in energy per crossing is 20%.

4 Integral flux

Show that the number of cosmic rays $\frac{N(E > E_0)}{dA dt d\Omega}$ above a certain energy (E_0) is also a power law.



5 Cosmic-ray rate per unit area

How many cosmic particles of energy between $E_0 = 100$ GeV and $E_1 = 101$ GeV do we expect per square meter and per second?