Experimental particle. physics

esipap

European School of Instrumentation
in Particle & Astroparticle Physics

A.

kinematics
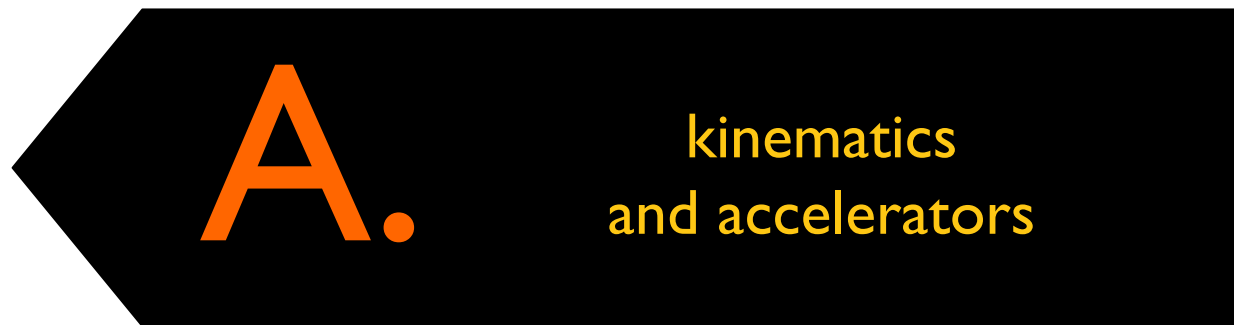and accelerators

Fixed target vs. collider
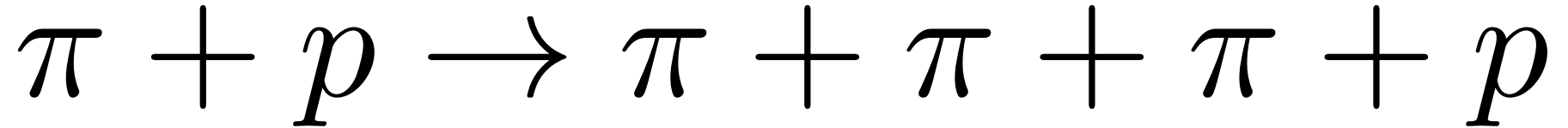
- How much energy should a fixed target experiment have to equal the center of mass energy of two colliding beam?

$$m_1 \qquad m_2$$
$$\longrightarrow \qquad \bullet$$
$$\mathbf{p}_1 \qquad \mathbf{p}_2 = \mathbf{0}$$

$$m_1 \qquad\qquad m_2$$
$$\longrightarrow \qquad \longleftarrow$$
$$\mathbf{p}_1' \qquad\qquad \mathbf{p}_2' = -\mathbf{p}_1'$$

$$E_{\mathrm{fix}} = 2\frac{E_{\mathrm{col}}^2}{m} - m$$

Reaction threshold

- What energy should the pion have for this reaction to happen?
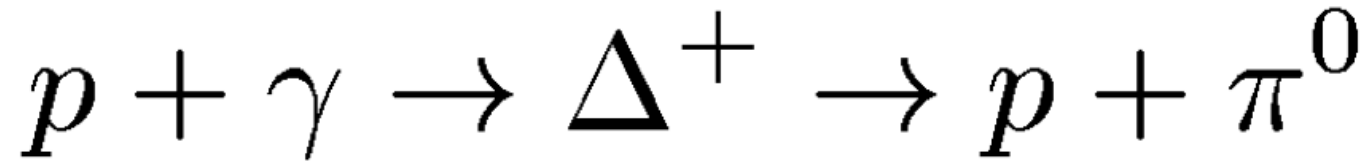
$$\pi + p \longrightarrow \pi + \pi + \pi + p$$

$$E_\pi \geq \frac{(\sum_i m_i c^2)^2 - (m_\pi c^2)^2 - (m_p c^2)^2}{2 m_p c^2} \simeq 500 \, \text{MeV}$$

Cosmic rays

- Protons with energy above the pion production threshold can produce them interacting with photons from relic cosmic radiation:
  - ✓ $E_\gamma \sim 10^{-3}$ eV

$$p + \gamma \to \Delta^+ \to p + \pi^0$$

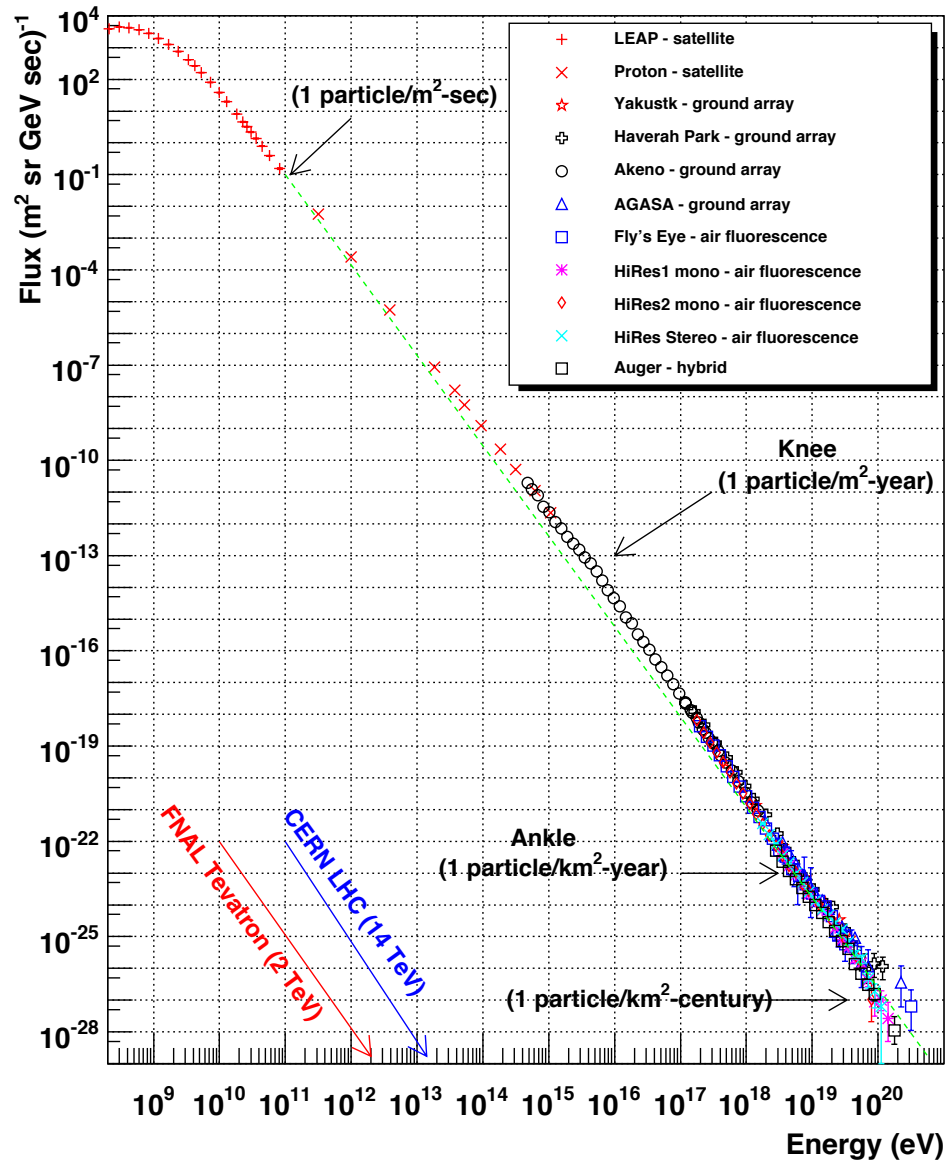**What is the maximum energy for a proton in the cosmic rays?**

This energy is called the CKZ (Greisen–Zatsepin–Kuzmin) cut-off: protons above this energy see the space as a opaque medium, and decelerate…

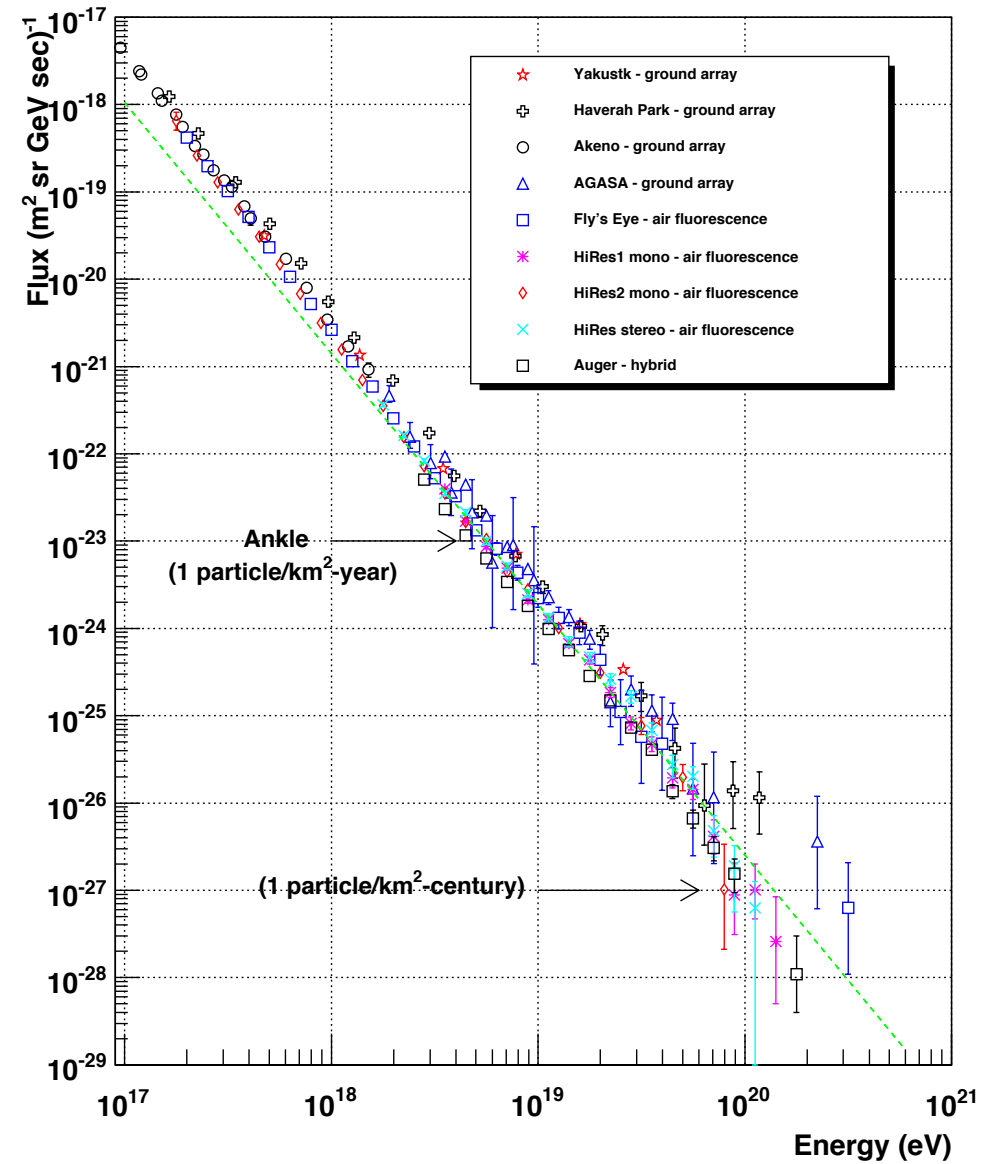- *Read this: First Observation of the Greisen-Zatsepin-Kuzmin Suppression*

Did we observed any extremely high-energetic cosmic rays above the CKZ cut-off?

- *Read this: The Particle That Broke a Cosmic Speed Limit*

Left panel legend:
- LEAP - satellite
- Proton - satellite
- Yakustk - ground array
- Haverah Park - ground array
- Akeno - ground array
- AGASA - ground array
- Fly's Eye - air fluorescence
- HiRes1 mono - air fluorescence
- HiRes2 mono - air fluorescence
- HiRes Stereo - air fluorescence
- Auger - hybrid

Right panel legend:
- Yakustk - ground array
- Haverah Park - ground array
- Akeno - ground array
- AGASA - ground array
- Fly's Eye - air fluorescence
- HiRes1 mono - air fluorescence
- HiRes2 mono - air fluorescence
- HiRes stereo - air fluorescence
- Auger - hybrid

Accelerators

- How much energy did electrons and positrons of E = 50 GeV and 100 GeV loose in one round at LEP?
  - ✓ L = 27 km

hint…

$$\Delta E = \frac{4\pi}{3} \frac{1}{4\pi\epsilon_0} \left(\frac{e^2 \beta^3 \gamma^4}{R} \right)$$

$$\frac{e^2}{4\pi\varepsilon_0 \hbar c} = \alpha$$

Muon lifetime and acceleration

- How long muon lifetime be in a muon beam of 200 GeV momentum?
- If we inject 10^{10} of such muons in a storage ring of R = 100 m, how many rounds would they do before beam intensity get reduced by a 10^6 factor?