Разбалловка

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ISPhO2026

Русский

Σ 0.0
Сумма баллов

A0 0.20 Using the given value of the radiation length of air X_0, calculate the splitting length d_e. Express your answer in g/cm^2 and round it to one decimal place.
Note: We will call the number of shower generations n the quantity, which denotes how many successive splittings have occurred since the beginning of the shower development.

1	The numerical answer obtained is $d_e = 25.1\ \mathrm{g/cm^2}$.	0.20	

A1 0.40 Determine the number of shower generations $n_{\max}$ after which the energy of the particles in the shower becomes less than the critical energy.

1	The following expression is written: $\log_2 \dfrac{E_\gamma}{E_e^{\text{crit}}}$.	0.20	
2	Rounding up was performed, yielding the final answer $n_{\max} = 7$.	0.20	
3	Rounding down was performed, yielding the answer $n_{\max} = 6$.	0.10	

A2 0.40 Determine the geometric distance l_e traveled by the shower (in m) in air by the time the maximum number of particles is reached.

1	The radiation path length is found as $x_e = d_e \cdot n_{\max}$.	0.15	
2	The following analytical expression is obtained: $l_e = \dfrac{x_e}{\rho_0}$.	0.15	
3	The numerical answer obtained is $l_e = 1.4\ \mathrm{km}$.	0.10	

A3 0.20 Determine the maximum number of particles $N_{\max}$ in the shower.

1	The following analytical expression is obtained: $N_{\max} = 2^{n_{\max}}$.	0.10	
2	The numerical answer obtained is $N_{\max} = 128$.	0.10	

A4 0.80 Determine the total charge Q_e (in C) carried by the electrons in the shower by the time its development ceases.

1	Any correct method for determining the number of electrons, n_{e^-} is presented.	0.40	

2	The solution obtains (or uses) the value $n_{e^-} = 43$.	0.10	
3	The following analytical expression is obtained: $Q_e = n_{e^-} \cdot q_e$.	0.10	
4	The numerical answer obtained is $Q_e = -6.9 \cdot 10^{-18}$ C.	0.20	
5	The correct numerical value was obtained, but with a positive sign: $Q_e = 6.9 \cdot 10^{-18}$ C.	0.10	

B1 0.40 Determine the maximum number of generations of the hadronic component of the shower, $n_{\text{hadr}}^{\max}$.

1	The following expression is written: $\log_{15} \dfrac{E_p}{E_\pi^{\text{crit}}}$.	0.20	
2	Rounding up was performed, yielding the final answer $n_{\text{hadr}}^{\max} = 3$.	0.20	
3	Rounding down was performed, yielding the final answer $n_{\text{hadr}}^{\max} = 2$.	0.10	

B2 1.00 Determine the maximum number of generations of the entire shower $n_{\text{EM}}^{\max}$, taking into account the electromagnetic component.

1	It is justified that the maximum number of generations in the entire shower is achieved in the electromagnetic shower that develops after the first hadronic interaction.	0.30	
2	It is taken into account that the energy of the electromagnetic shower after the first hadronic interaction is reduced by a factor of 15.	0.20	
3	It is taken into account that the photons initiating the electromagnetic shower have energies that are a factor of 2 lower than the energies of the neutral pions.	0.20	
4	The following expression is written: $\log_2 \dfrac{E_p/(15 \cdot 2)}{E_e^{\text{crit}}}$.	0.10	
5	The numerical answer obtained is $n_{\text{EM}}^{\max} = 13$	0.20	
6	A numerical answer was obtained without rounding up, or the first hadronic generation was omitted.	0.10	

B3 0.60 Determine the fraction of the shower energy carried away by muons and neutrinos, β_{miss}. Round your answer to two decimal places.

1	It is stated that the fraction of energy carried away by muons and neutrinos is equal to the fraction of charged pions among the total number of particles in the shower.	0.20	
2	The following analytical expression is obtained: $\beta_{\text{miss}} = \left(\dfrac{3}{5}\right)^{n_{\text{hadr}}^{\max}}$.	0.20	
3	The numerical answer obtained is $\beta_{\text{miss}} = 0.22$	0.20	

C1 1.30 Determine the altitude h_{stop} at which the shower development ceases. Express your answer in kilometers and round it to one decimal place.

1	It is stated that h_{stop} is calculated for the electromagnetic component of the shower.	0.10	
2	The following expression is obtained for the number of generations in the electromagnetic component: $\log_2 \dfrac{E/(15 \cdot 2)}{E_e^{\text{crit}}}$.	0.10	
3	The following expression is obtained for the total radiation path length of the shower: $x = d_h + 16 \cdot d_e$.	0.30	
4	An expression for the geometrical path length is written, and the integral is evaluated: $x = \rho_0 H e^{-h_{\text{stop}}/H}$.	0.30	
5	The following analytical expression is obtained: $h_{\text{stop}} = H \ln \dfrac{\rho_0 H}{x}$	0.30	

6	The numerical answer obtained is $h_{\text{stop}} = 6.6\ \text{km}$	0.20	

C2 0.50 Determine what fraction of the shower energy, β_{EM}, ends up in the electromagnetic component. Round your answer to two decimal places.

1	It is stated that all energy not carried away by muons and neutrinos goes into the electromagnetic component.	0.10	
2	The following expression is written: $\log_{15} \dfrac{E}{E_\pi^{\text{crit}}}$.	0.10	
3	The value obtained is $n_h = 4$.	0.10	
4	The following analytical expression is obtained: $\beta_{\text{EM}} = 1 - \left(\dfrac{9}{15}\right)^{n_h}$	0.10	
5	The numerical answer obtained is $\beta_{\text{EM}} = 0.87$	0.10	

C3 0.20 Estimate the shower radius R_{stop} at the altitude h_{stop}. Express your answer in meters and round it to the nearest integer.

1	The following analytical expression is obtained: $R_{\text{stop}} = \dfrac{X_0}{\rho_0 e^{-h_{\text{stop}}/H}} \cdot \dfrac{E_s}{E_e^{\text{crit}}}$	0.10	
2	The numerical answer obtained is $R_{\text{stop}} = 150\ \text{m}$	0.10	

C4 0.20 Estimate the area of the shower S at the Earth's surface. Express your answer in m^2 and keep 2 significant figures.

1	The following expression is written for the shower radius at the Earth's surface: $R = R_{\text{stop}} \dfrac{\rho}{\rho_0}$.	0.10	
2	The numerical answer obtained is $S = 14 \cdot 10^3\ \text{m}^2$	0.10	

C5 0.80 Estimate the characteristic signal duration Δt at a detector located on the Earth's surface at the center of the shower. Express your answer in ns and round it to one decimal place.

1	The following relation is written: $\Delta = h_{\text{stop}} \cdot (1 - \cos\theta)$, or $\Delta = h_{\text{stop}} \cdot \dfrac{1 - \cos\theta}{\cos\theta}$.	0.40	
2	The following relation is written: $\Delta t = \dfrac{\Delta}{c}$.	0.10	
3	The following analytical expression is obtained: $\Delta t = \dfrac{R_{\text{stop}}^2}{2ch_{\text{stop}}}$, or another correct formula without using the small-angle approximation.	0.20	
4	The numerical answer obtained is $\Delta t = 5.7\ \text{ns}$	0.10	

D1 1.00 Determine the coefficient κ of the detector at the Earth's surface.

1	The idea to draw a histogram of the detector signal amplitudes in order to determine the amplitude corresponding to the critical energy.	0.50	
2	The amplitude corresponding to the critical energy is determined from the maximum amplitude recorded in the table.		0.20
3	It is found that the histogram exhibits a sharp cutoff at $A^{\text{crit}} = 1.32 \cdot 10^8$.	0.20	
4	The following expression is written: $\kappa = \dfrac{A^{\text{crit}}}{E_e^{\text{crit}}}$.	0.10	

5	The numerical answer obtained is $\kappa = 1.5 \cdot 10^9\ \mathrm{GeV}^{-1}$	0.20	

D2 0.50 Determine the energy of the initial photon E_0.

1	It is proposed to consider the total signal recorded by the detector.	0.20	
2	The total signal amplitude obtained is $A_0 = 70240347424.$	0.10	
3	The following expression is written: $E_0 = \dfrac{A_0}{\kappa}.$	0.10	
4	The numerical answer obtained is $E_0 = 46.8\ \mathrm{GeV}$	0.10	

D3 1.50 Calculate the atmospheric density at the Earth's surface ρ_{atm}.

1	The idea to determine the atmospheric density from the shower radius.	0.70	
2	The shower radius at the detector is calculated to be $R = 68.3\ \mathrm{m}.$	0.40	
3	The following expression for the atmospheric density is obtained from the shower radius: $\rho_{\mathrm{atm}} = \dfrac{X_0}{R} \cdot \dfrac{E_s}{E_e^{\mathrm{crit}}}.$	0.20	
4	The numerical answer obtained is $\rho_{\mathrm{atm}} = 1.26\ \mathrm{kg/m^3}$	0.20	