1st test FPar (2016/2017)

1- a) Allowed

b) Not allowed as it violates strangeness

c) Allowed

d) Not allowed as it violates charge and baryonic number

e) Possible as it doesn't violate any quantum number

2- a) $\mathcal{L} = N_p f N_t$ with $N_t = N_A \frac{\rho \Delta x}{W_a} \times n$

W_a - is the atomic weight

n - number of protons in H_2

$\Rightarrow \mathcal{L} = 1{,}28 \times 10^{34} \ cm^{-2} \ s^{-1}$

$\Rightarrow N_{Kaons} = \mathcal{L} \, \Delta t \, \sigma =$

$= 1{,}28 \times 10^{34} \times (60 \times 60) \times 400 \times 10^{-6} \times 10^{-24} =$

$= 1{,}84 \times 10^{10}$ Kaons per hour

2-

b) The number of interactions depends on

- cross-section of the interaction
- number of projectiles
- number of targets

Hence, one could measure, for instance, the number of produced kaons to have an idea of the amount of "activity" and from that estimate the number of interactions.

Let's call this quantity, N.

In that case,

→ Container filled with $H_2 \equiv N_{tot}$

→ Container empty $\equiv N_{Mylar}$

And the number of interactions in the H_2 is $N_{H_2} = N_{tot} - N_{Mylar}$

3 - a) $\pi^0 e^+ \nu_e \rightarrow 5{,}07\%$

$\pi^+ \mu^+ \nu_\mu \rightarrow 3{,}35\%$

$\pi^+ \pi^0 \rightarrow 20{,}67\%$

$\pi^+ \pi^0 \pi^0 \rightarrow 1{,}76\%$

Summing all channels one gets $30{,}79\%$ //

b) $P_K = 1\ GeV/c$; $c\tau_K = 3{,}712\ m$, $m_K = 493{,}7\ MeV/c^2$

$$x = vt = \beta c t = \frac{P}{E} c t = \frac{P}{E} c \gamma \tau = \frac{P}{E} \frac{E}{m} c\tau$$

$$\Rightarrow \quad x = \frac{P}{m} c\tau = 7{,}52\ m \quad \text{for all decay modes}$$

4 - a) $\cos\theta = \dfrac{1}{\beta n} \leq 1 \Leftrightarrow n \geq \dfrac{1}{\beta} = \dfrac{E}{P}$

$$n \geq \frac{\sqrt{P^2 + m_K^2}}{P} = 1{,}115$$

b) $m_i \geq \dfrac{\sqrt{p^2 + m_i^2}}{p}$ As P is the same for all π, K, p

Since $m_\pi < m_K < m_p$

$\Rightarrow$ $m_1 \in [m_\pi ; m_K[$ so that only pions are "seen"

$m_2 \in [m_K ; m_p[$ so that only pions and kaons are "seen"

The separation could be done through

C_1	C_2	
1	1	$\rightarrow \pi$
0	1	$\rightarrow k$
0	0	$\rightarrow p$

with (0) $\nexists$ signal ; (1) $\exists$ signal

5) a) LAB: before interaction $\xrightarrow{p_1} \cdot\, m_p$

$$p_\mu = (T + 2m_p,\ p_1)$$

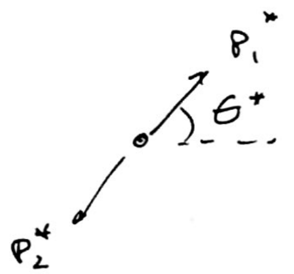
$$s = p_\mu p^\mu = (T+2m_p)^2 - p_1^2 = (E_1 + m_p)^2 - p_1^2 =$$

$$= E_1^2 + m_p^2 + 2m_p E_1 - p_1^2 = 2m_p^2 + 2m_p(T + m_p)$$

$$= 4m_p^2 + 2m_p T \Rightarrow \sqrt{s} = 2{,}93 \text{ GeV}$$

The energy necessary to produce ppK^+K^- is

$2m_p + 2m_K = 2{,}86$ GeV $< \sqrt{s} \Rightarrow$ reaction is possible //

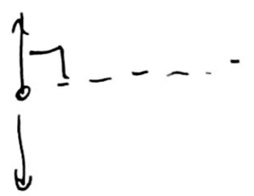
b) i) 

CM framework (ϕ)

$$p_\mu = (m_\phi, \vec{0}) = (E_1^* + E_2^*, \vec{0})$$

since $E_1^* = E_2^* \Rightarrow E_1^* = E_2^* = \dfrac{m_\phi}{2}$

and $|p_1^*| = |p_2^*| = \sqrt{E_1^{*2} - m_K^2} = 128$ MeV/c

b) ii) 

boost ($p_\phi = 1$ GeV/c)

$$\begin{pmatrix} E \\ p_\ell \end{pmatrix} = \begin{pmatrix} \gamma & \gamma\beta \\ \gamma\beta & \gamma \end{pmatrix} \begin{pmatrix} E^* \\ p_\ell^* \end{pmatrix}$$

$$p_\ell = \gamma\beta E_K^* + \underbrace{\gamma p^* \cos\theta^*}_{=0} = \gamma\beta E_K^*$$

and $p_T = p_K^*$; $\gamma\beta = \dfrac{E_\phi}{m_\phi}\dfrac{p_\phi}{E_\phi} = \dfrac{p_\phi}{m_\phi}$

$$P_K = \sqrt{P_\ell^2 + P_T^2} = \sqrt{\left(\frac{P_\phi}{m_\phi} E_K^*\right)^2 + P_K^{*2}} = 516,2 \text{ MeV}/c$$

b) iii) Reaction: $p \quad p \rightarrow p \quad p \quad K^+ \quad K^-$

4-vector: $(P_1) \; (P_2) \qquad (P_3) \; (P_4) \; (P_{K^+}) \; (P_{K^-})$

Then, $P = P_1 + P_2 = P_3 + P_4 + P_{K^-} + P_{K^+}$

Supposing that we know all 4-vectors except P_3, then, $P_3 = P - (P_4 + P_{K^+} + P_{K^-})$

If one now takes the square of the 4-vector

$(P_3)^2 = E_3^2 - P_3^2 = m_3^2$, which should be the square of the proton mass