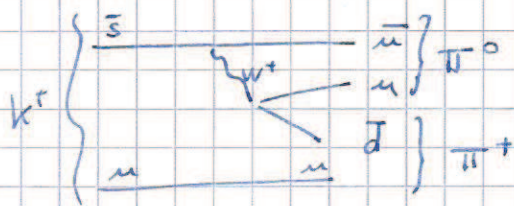
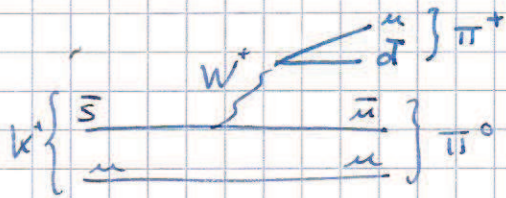
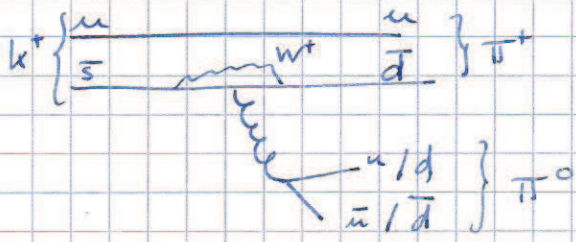


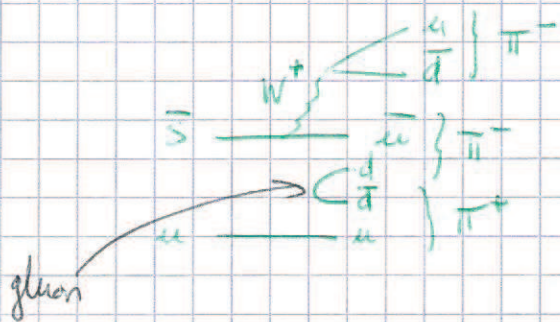
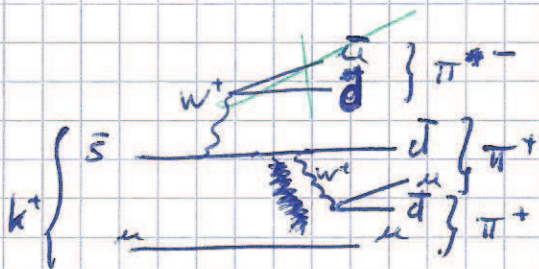
12. énergie ok
 Q ok
 saveur violée → if?

k^+ π^+ π^0
 $\bar{s}u$ $u\bar{d}$ $u\bar{u}/d\bar{d}$

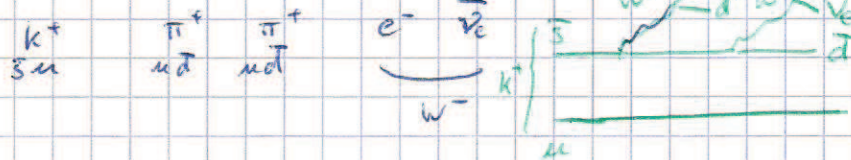


13. énergie ok
 Q ok
 saveur violée → if?

k^+ π^+ π^- π^+
 $\bar{s}u$ $u\bar{d}$ $\bar{u}d$ $u\bar{d}$



14. non

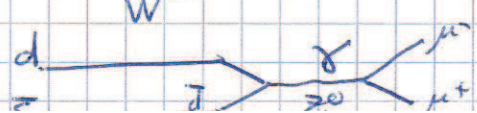
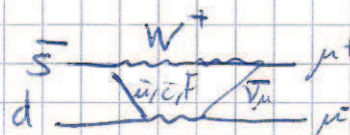
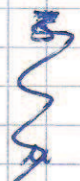
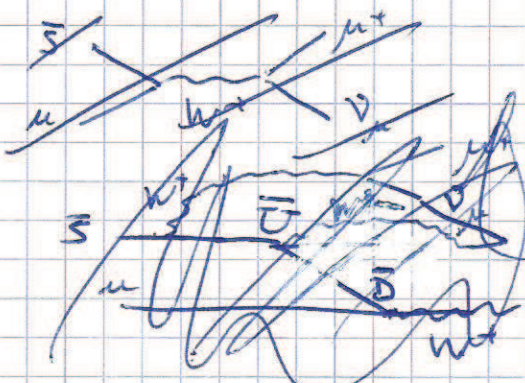


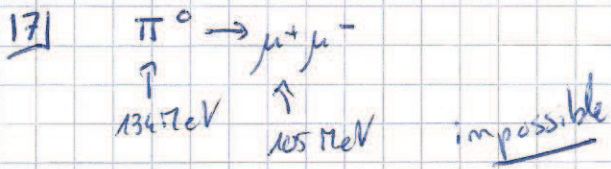
15. L non

16. saveur non → if?



$K^0 \rightarrow \mu^+ \mu^-$
 $\bar{s}d$





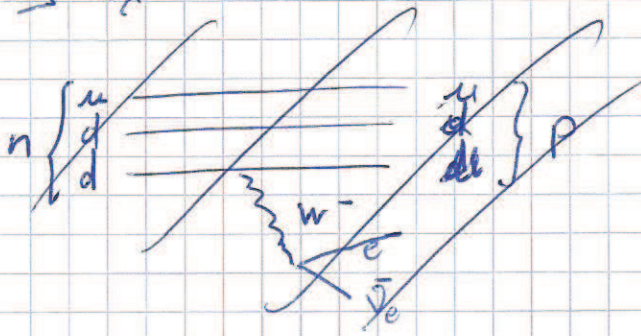
18) L non

19) L non

20) energie non

21) Q

Q non

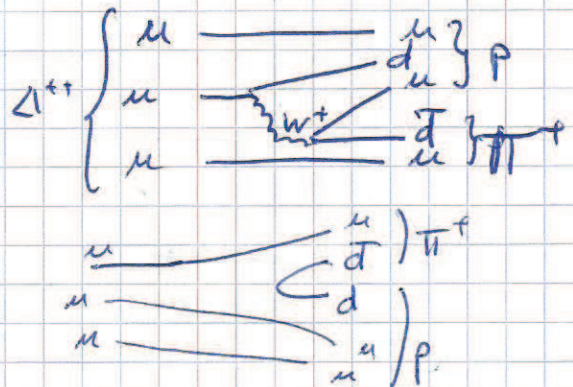
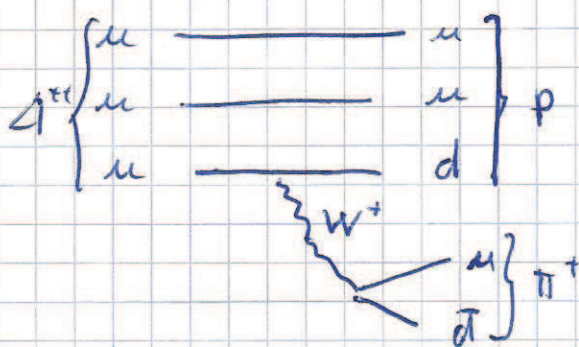


22) Δ^{++} Q non
 uuu

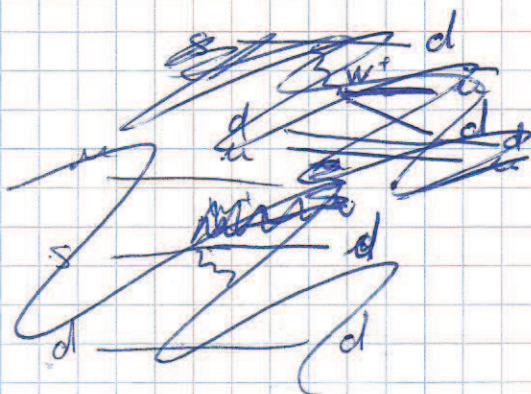
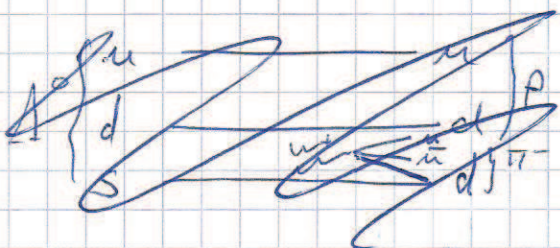
23) Δ^{++} P π^+
 uuu uud $u\bar{d}$ Q non

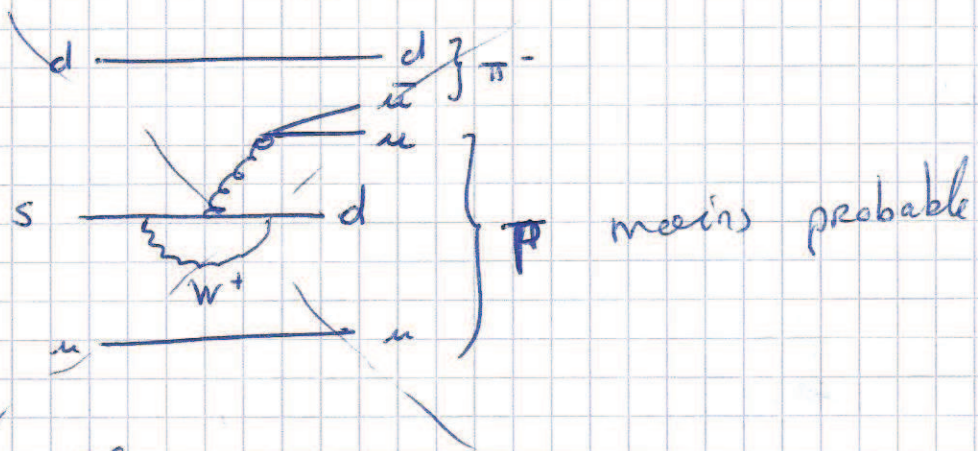
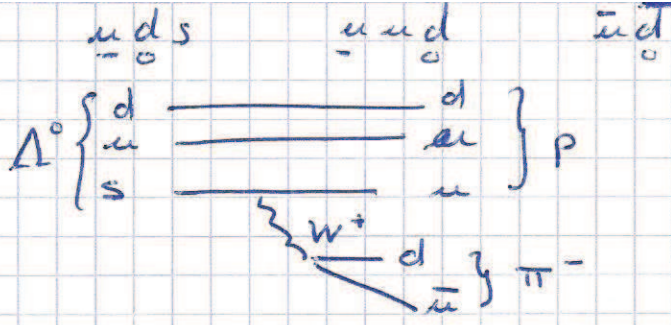
Q	+2	+1	+1
B	1	1	0

energie ord \uparrow 1230 MeV \uparrow 938 MeV \uparrow 134 MeV

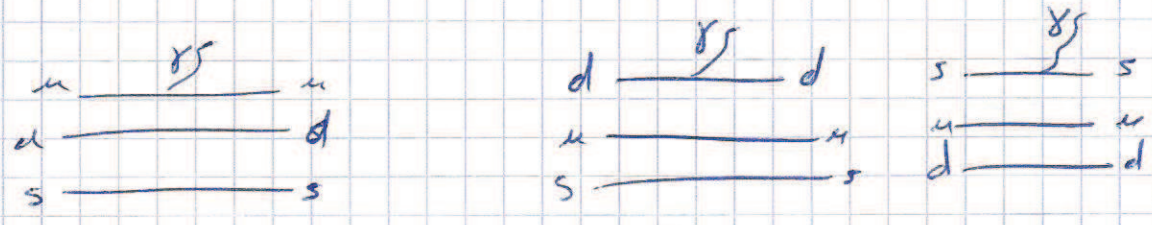


24) Λ^0 P π^-
 uds uud $\bar{u}d$

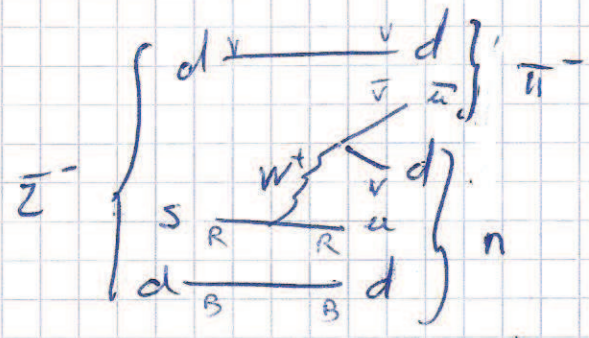
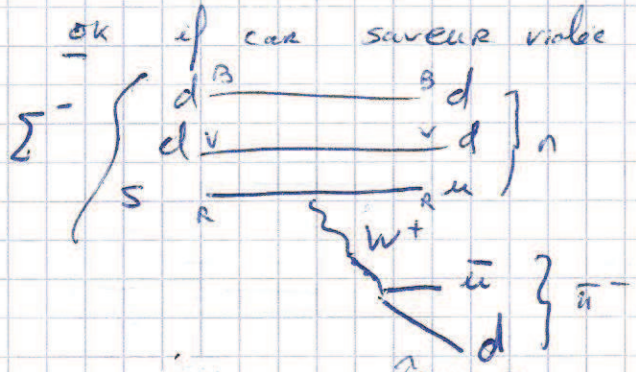




25) Σ^0 $\left\{ \begin{array}{l} u \\ d \\ s \end{array} \right\} p$



26) Σ^- $\left\{ \begin{array}{l} d \\ d \\ s \end{array} \right\} n$ $\left\{ \begin{array}{l} u \\ d \\ \bar{u} \end{array} \right\} \pi^-$



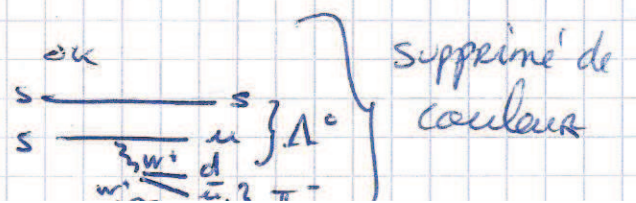
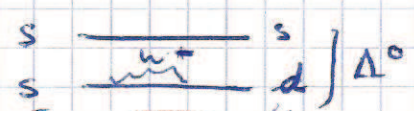
3 couleurs possibles

supprimé de couleur

27) Ω^- $\left\{ \begin{array}{l} s \\ s \\ s \end{array} \right\} \Lambda^0$ $\left\{ \begin{array}{l} u \\ d \\ \bar{u} \end{array} \right\} \pi^-$

B	1	1	0
Q			
Q	-1	0	-1
	1672 MeV	1115 MeV	

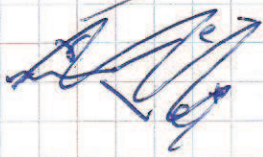
saveur non



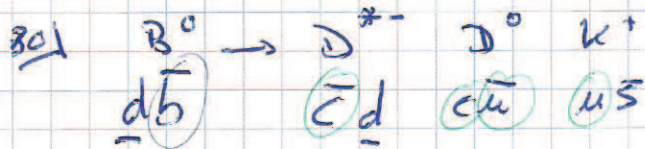
$$28) \quad \pi^+ \quad \mu^- \quad e^+ e^+ \quad \nu_\mu$$

Le non

$$29) \quad \gamma \rightarrow e^- e^+$$



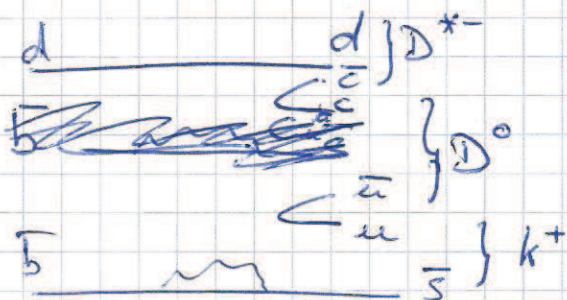
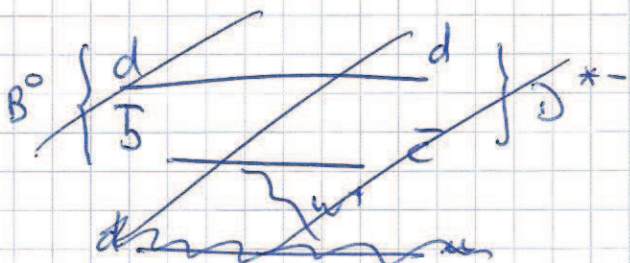
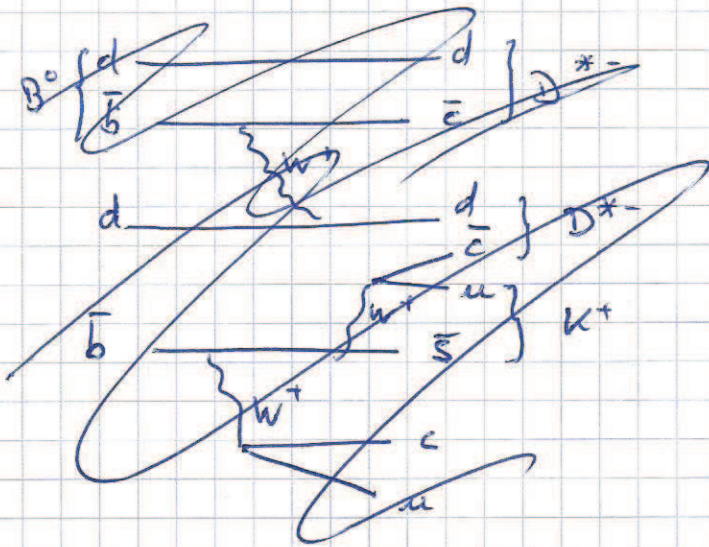
énergie non
non conservée de l'impulsion



Q	0	-1	0	1
B	0	0	0	0

vide saveur

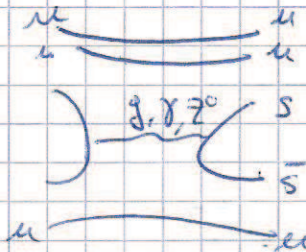
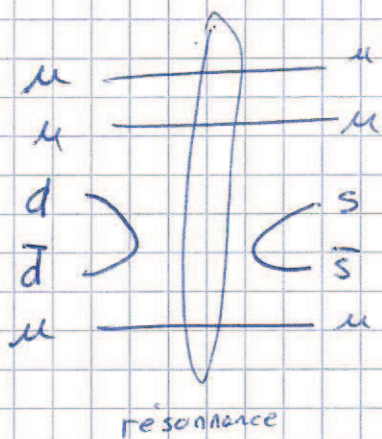
\rightarrow 5000 MeV 1860 1860 MeV 495 MeV



31) $\bar{\nu}^+ n \rightarrow \bar{\nu}_c^+ \Delta^0 p^+$
 \otimes non

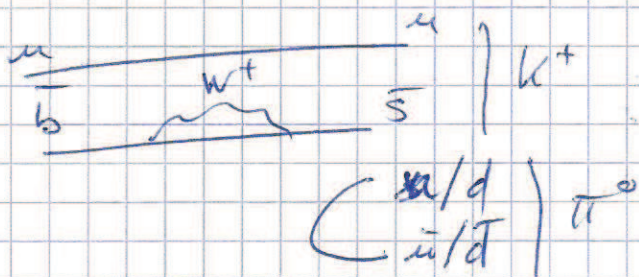
32) $\pi^+ p \rightarrow k^+ \bar{\Sigma}^+$
 ad und su sein

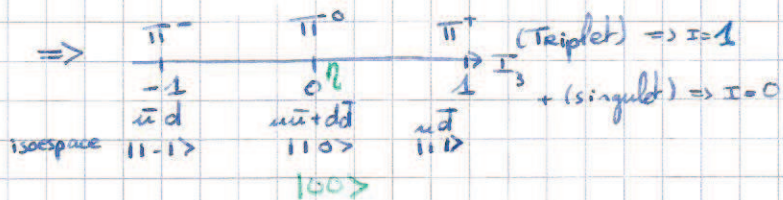
saveur conservé



33) \otimes non
 \otimes non

34) $B^+ \quad K^+ \quad \pi^0$
 $u\bar{b} \quad \bar{s}u \quad u\bar{u} \in d\bar{d}$ if

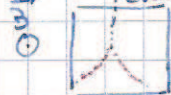




2) Spectre des baryons

a) Formule de Gell-Mann - Nishijima

la découverte du quark "s",



puis des autres quarks, ce qui entraîne la relation suivante:

$$Q = I_3 + \frac{Y}{2}$$

charge électrique

hypercharge avec $Y = \frac{2}{3} + S + C + B + T$

la définition de l'hypercharge est conservée par l'IF.

ex:

$$I_3(u) = \frac{1}{2}; Q(u) = +\frac{2}{3}e; S(u) = 1 \Rightarrow Y(u) = \frac{1}{3}$$

$$I_3(d) = -\frac{1}{2}; Q(d) = -\frac{1}{3}e; S(d) = 1 \Rightarrow Y(d) = \frac{1}{3}$$

$$I_3(s) = 0; Q(s) = -\frac{1}{3}e; S(s) = -1 \Rightarrow Y(s) = -\frac{2}{3}$$

b) SU(3) de la saveur

• Hypothèse: la symétrie d'isospin est étendue jusqu'au s.

Pour l'IF, u, d et s sont identiques

↳ on postule q les hadrons composés de quarks choisis parmi u, d et s sont invariants sous une transformation SU(3)_{saveur}

Une transformation qq de SU(3) s'écrit: • unitaire $U^\dagger U = U U^\dagger = 1$

• spéciale $\det(U) = 1$

↳ 8 paramètres
(3 param $\in \mathbb{C}$)

8 générateurs

$$U = \exp\left(\frac{i}{2} \sum_{i=1}^8 \alpha_i J_i\right)$$

générateurs
paramètres

pour une transf. qq

$$J_1 = \begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

$$J_2 = \begin{pmatrix} 0 & -j & 0 \\ j & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

$$J_3 = \begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

$$J_4 = \begin{pmatrix} 0 & 0 & 1 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \end{pmatrix}$$

$$J_5 = \begin{pmatrix} 0 & 0 & -j \\ 0 & 0 & 0 \\ j & 0 & 0 \end{pmatrix}$$

$$J_6 = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}$$

$$J_7 = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & -j \\ 0 & j & 0 \end{pmatrix}$$

$$J_8 = \frac{1}{\sqrt{3}} \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -2 \end{pmatrix}$$

On appelle u, d et s les vecteurs propres communs

$$I_3 |u\rangle = \frac{1}{2} |u\rangle$$

$$Y |u\rangle = \frac{1}{3} |u\rangle$$

$$I_3 |d\rangle = -\frac{1}{2} |d\rangle$$

$$Y |d\rangle = \frac{1}{3} |d\rangle$$

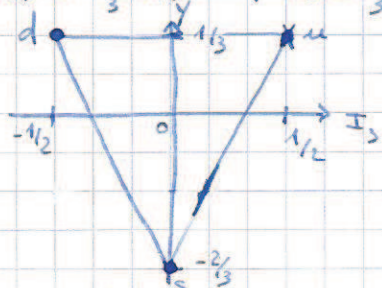
$$I_3 |s\rangle = 0 |s\rangle$$

$$Y |s\rangle = -\frac{2}{3} |s\rangle$$

$$I_3 = \frac{J_3}{2} \text{ et } Y = \frac{1}{\sqrt{3}} J_8$$

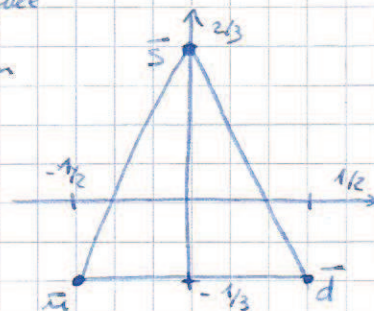
à $\frac{1}{\sqrt{3}}$ près, on retrouve ici l'hypercharge de u, d et s

En représentation,



Représentation $\underline{3}$

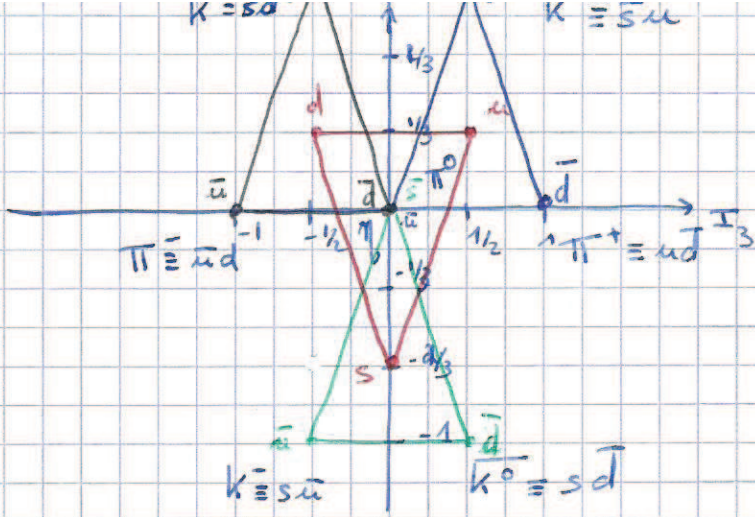
on prend la complexe conjuguée de la base représentation



Représentation $\bar{3}$

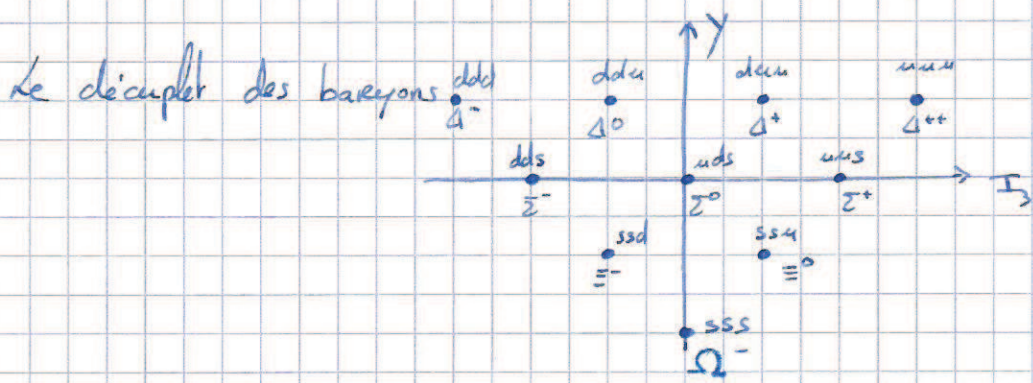
Pour fabriquer les mésons, il suffit de faire le produit tensoriel de 2 espaces: Méson = Repr $\underline{3} \otimes$ Repr $\bar{3} = 8 + 1$





Triplet d'isospin $\begin{matrix} \pi^- \\ |1, -1\rangle \\ \bar{K}^0 \\ |1, 0\rangle \\ \pi^+ \\ |1, 1\rangle \end{matrix}$

Doublet d'isospin $\begin{matrix} K^- \\ |\frac{1}{2}, \frac{1}{2}\rangle \\ \bar{K}^0 \\ |\frac{1}{2}, -\frac{1}{2}\rangle \end{matrix}$



Puis on rajoute le quark c \Rightarrow SU(4) saveurs (pdg p. 210)

IV) Phénoménologie de l'IF

1) La couleur

• $m_u \neq m_d$ entre les quarks met un terme à la symétrie d'isospin. Mais c'est malgré tout une "bonne" symétrie pour l'IF
 Comment mettre 3 quarks identiq ds les particules $\Omega^-, \Delta^-, \Delta^{++}$ sachant q $L_{relatif} = 0$

Solution : on rajoute un nouveau nbre quantiq

$\Delta^{++} = \uparrow\uparrow\uparrow_{spin}$ \rightarrow il faut un nbre quantiq à 3 valeurs
 |rouge> |vert> |bleu>
 \nwarrow c'est la charge pour l'IF \nearrow

2) SU(3) couleur

* vecteurs de base sont $|r\rangle, |v\rangle, |b\rangle$

- { \bar{a} 1 quark \rightarrow une couleur
- { \bar{a} 4 antiquark \rightarrow une anticouleur

+ l're particule observable doit être invariante sous l're transformation de SU(3) couleur
 \Rightarrow singulet de couleur \Rightarrow blancs

des particules observables sont $q_R \bar{q}_R, q_R q_V q_B, q\bar{q}, q_R q_V q_B \bar{q}_R \bar{q}_R, q_R q_V q_B \bar{q}_R \bar{q}_B, q\bar{q}$