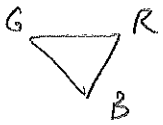
Quantum chromodynamics (QCD) 1973

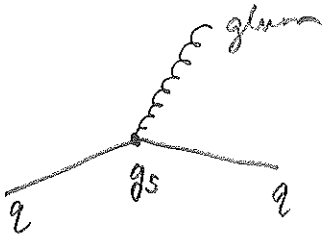
Quarks belong to $\underset{\sim}{3}$ of $SU(3)_{color}$



"fundamental" representation

"Color is the charge of the strong force.

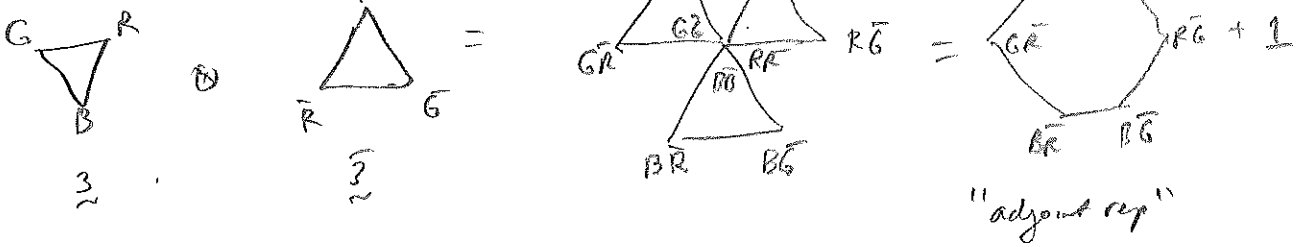
QCD vertex



g_s = strong coupling constant $(g_s \gg e, g_w)$

Gluons belong to $\underset{\sim}{8}$ of $SU(3)_{color}$

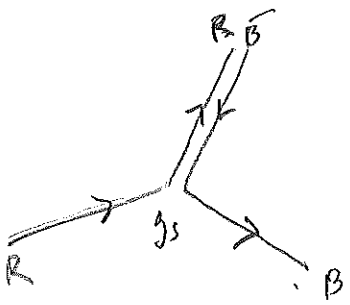
Recall



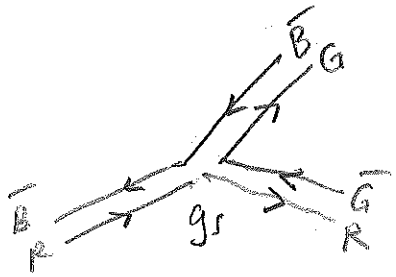
$\underset{\sim}{3}$ ⊗ $\underset{\sim}{\bar{3}}$ = "adjoint rep"

A gluon has a color + anticolor. Represent by double line

[use colored chalk]



quark-quark gluon vertex

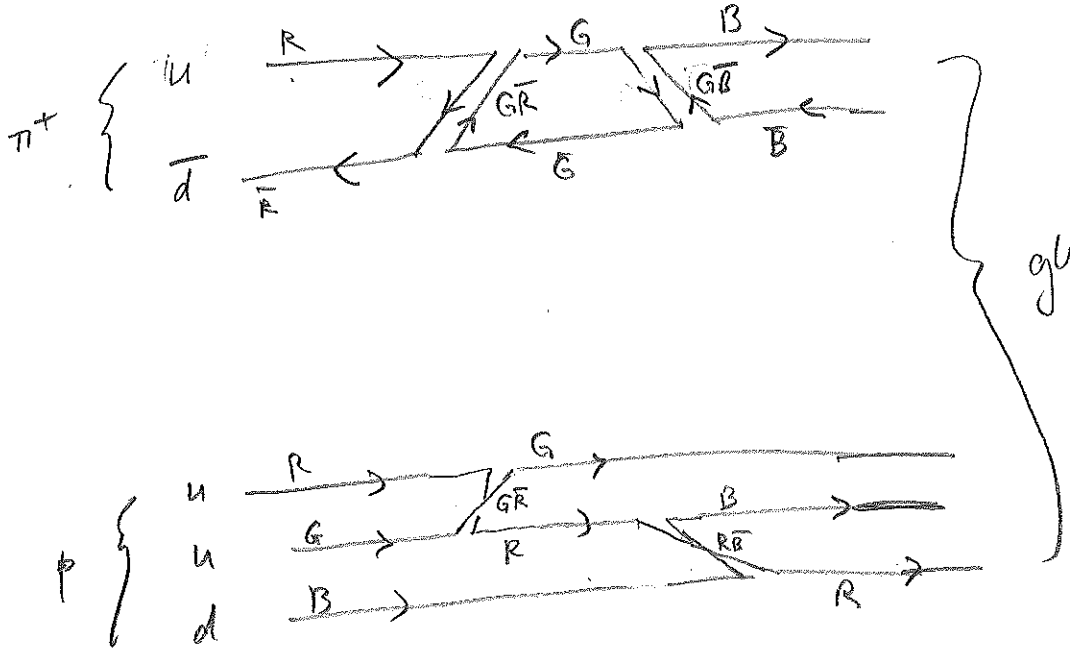


3 gluon vertex

Hadrons (baryons + mesons) are color singlets
transform in the $\underline{1}$ of SU(3) color

mesons: $\frac{1}{\sqrt{3}}(R\bar{R} + G\bar{G} + B\bar{B})$

baryons $\frac{1}{\sqrt{6}}$ (RGB ± perms)

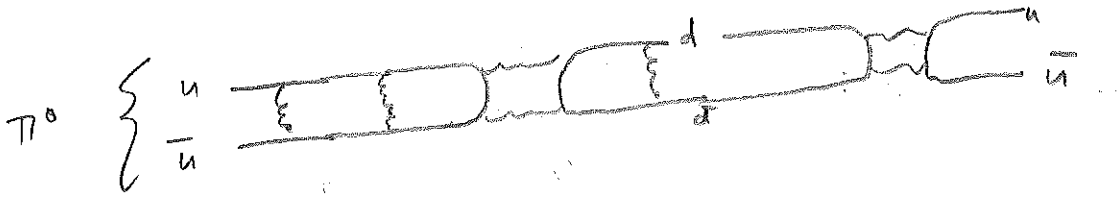


exchange of gluons allow quarks to change color
but not flavor, so strangeness, etc are
conserved in strong interactions

Recall $\pi^+ = u\bar{d}$

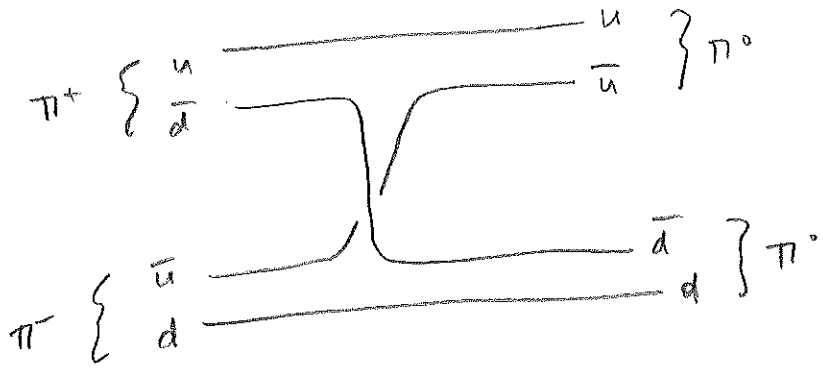
$\pi^- = d\bar{u}$

$\pi^0 = \frac{1}{\sqrt{2}}(u\bar{u} - d\bar{d})$



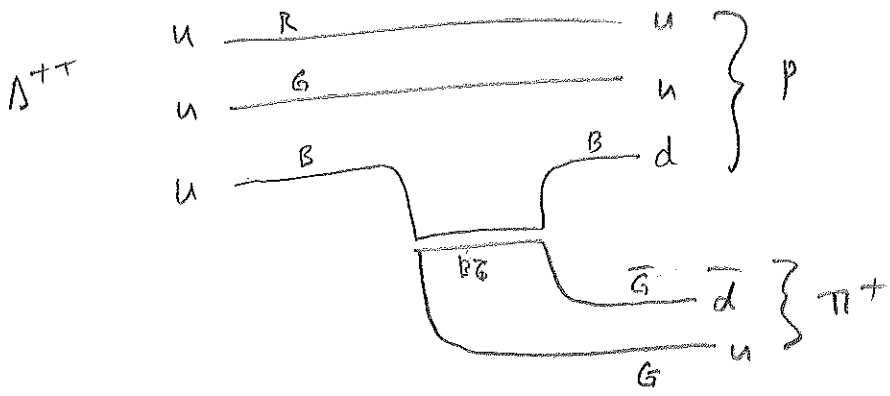
So $u\bar{u} \rightarrow d\bar{d} \rightarrow u\bar{u}$ via gluons.

$\pi^+\pi^- \longrightarrow \pi^0\pi^0$ via quark exchange



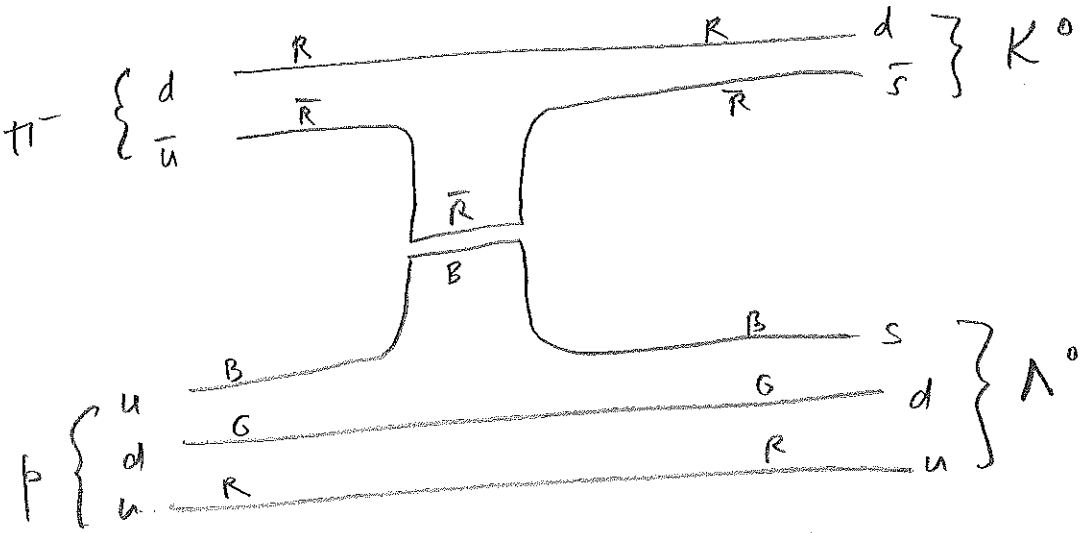
Pair production of $q\bar{q}$ from gluon

$\Delta^{++} \longrightarrow p\pi^+$ (strong decay)



Associated production (strong interaction)

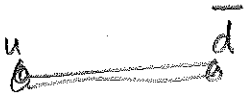
$\pi^- p \longrightarrow \Lambda^0 K^0$



Quark confinement

Try to pull two quarks apart

π^+ $u\bar{d}$

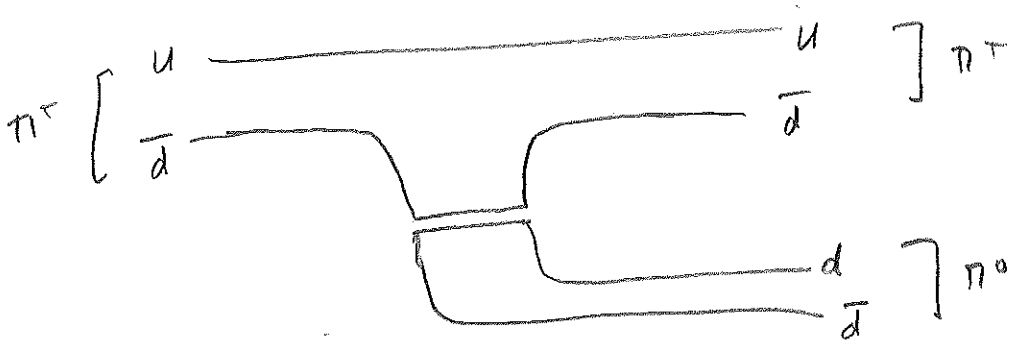


[increased energy]

$F_0 \approx 16 \text{ tons} = 1.5 E5 \text{ N}$

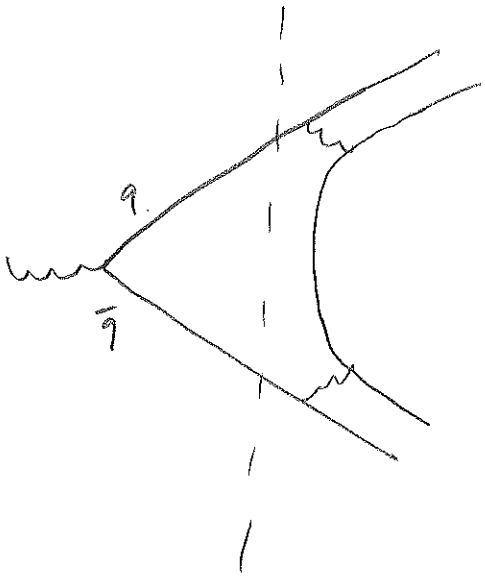
$= 10^{18} \frac{\text{MeV}}{\text{m}} = \frac{1000 \text{ MeV}}{\text{fm}}$

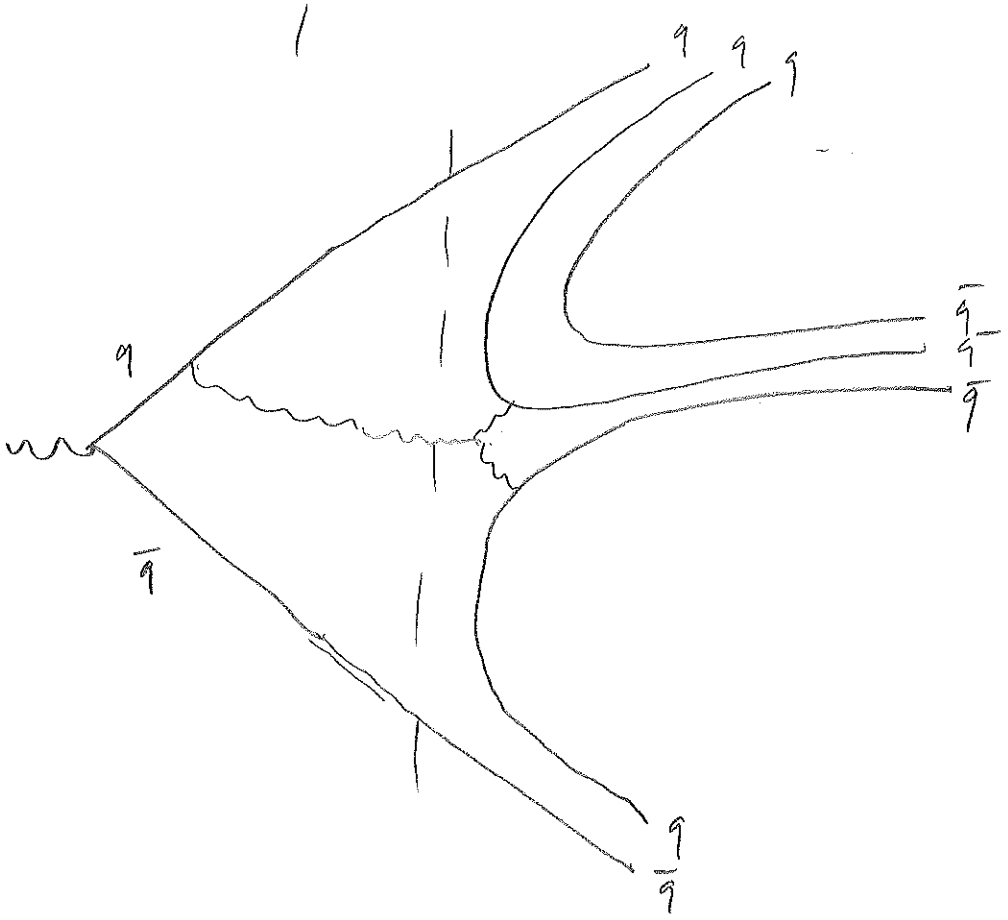
$\pi^+ + \pi^0$



"hadronization"

Hadronization





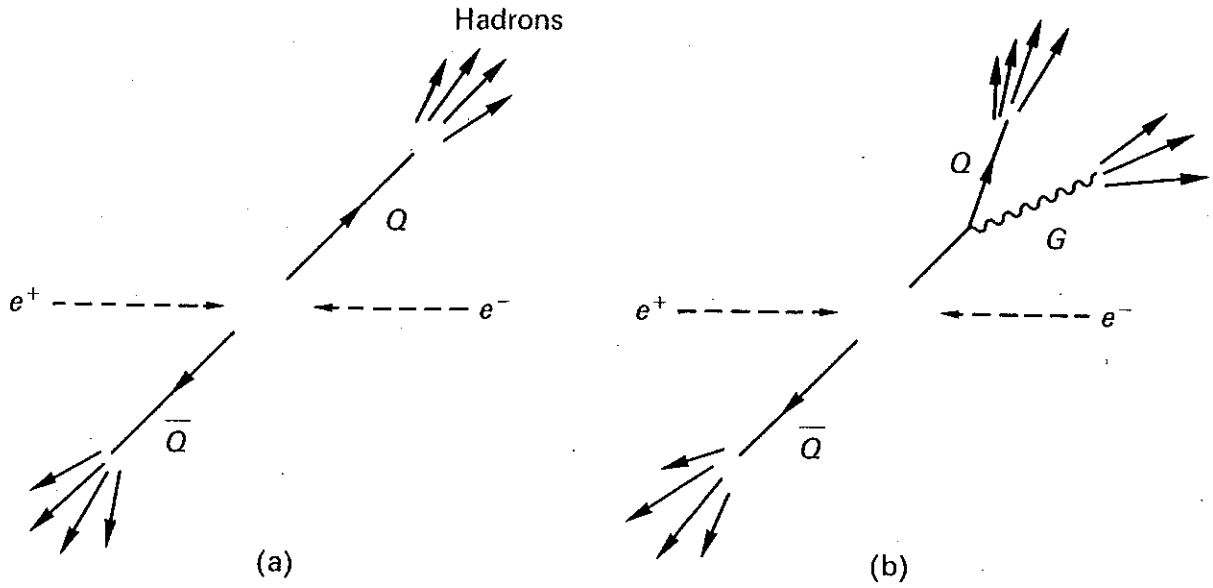


Fig. 8.27

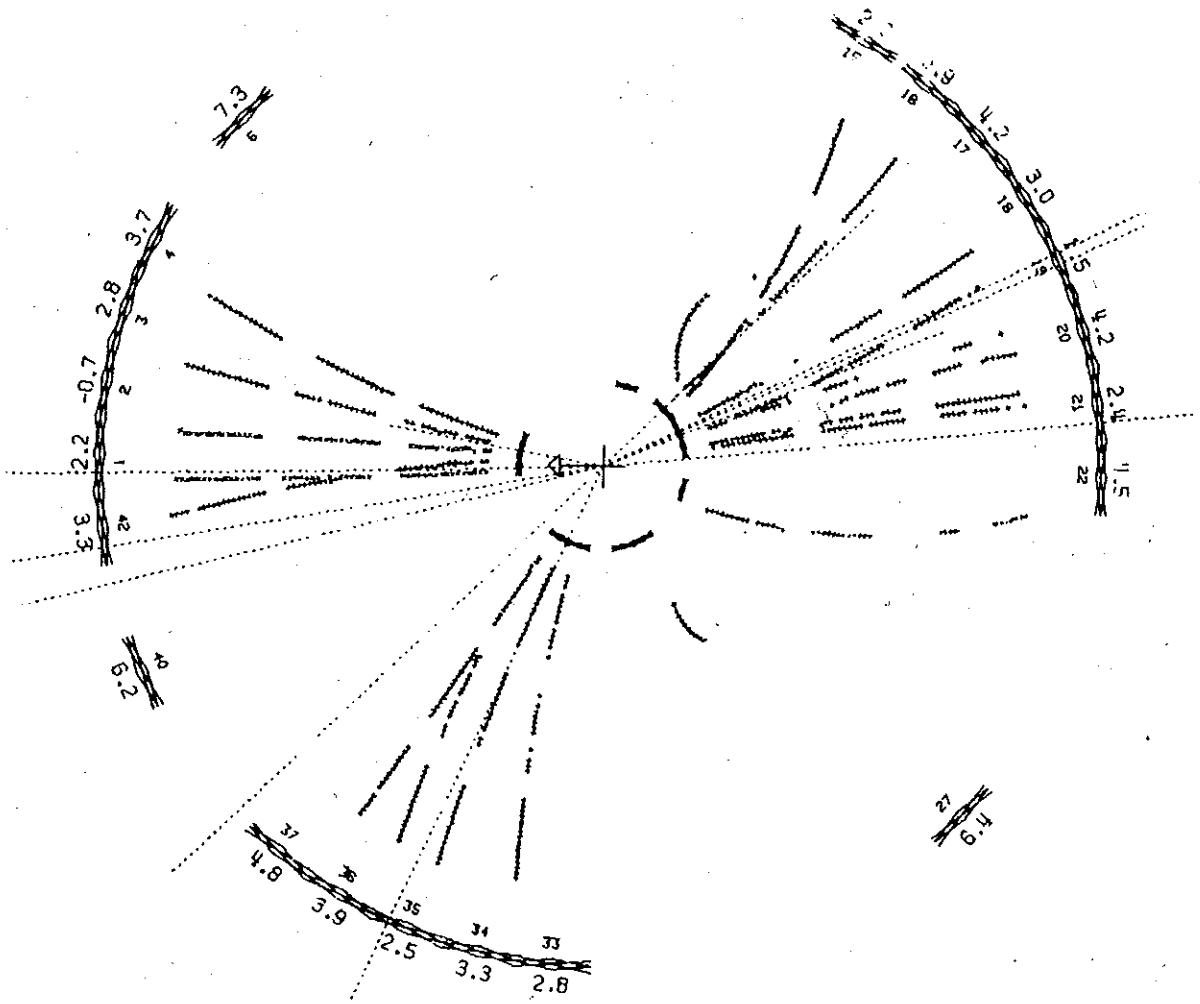


Fig. 8.28 Example of a three-jet event observed in the JADE detector at the PETRA e^+e^- collider

Perkins

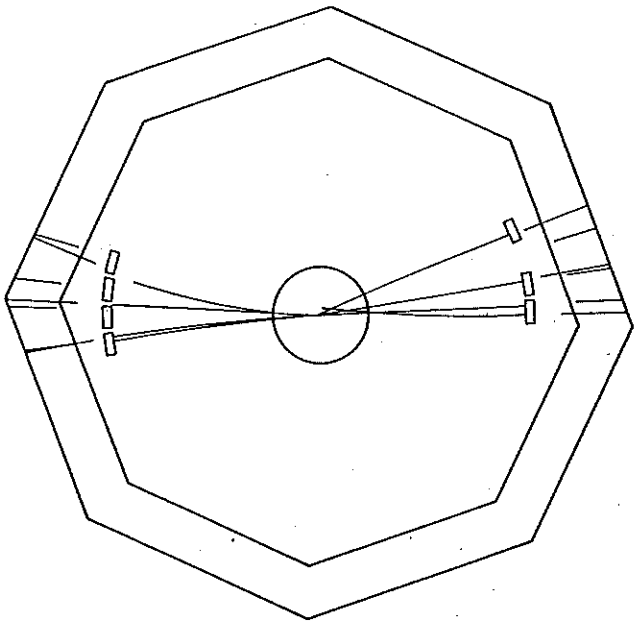


Figure 8.1 A typical two-jet event. (Courtesy J. Dorfan, SLAC.)

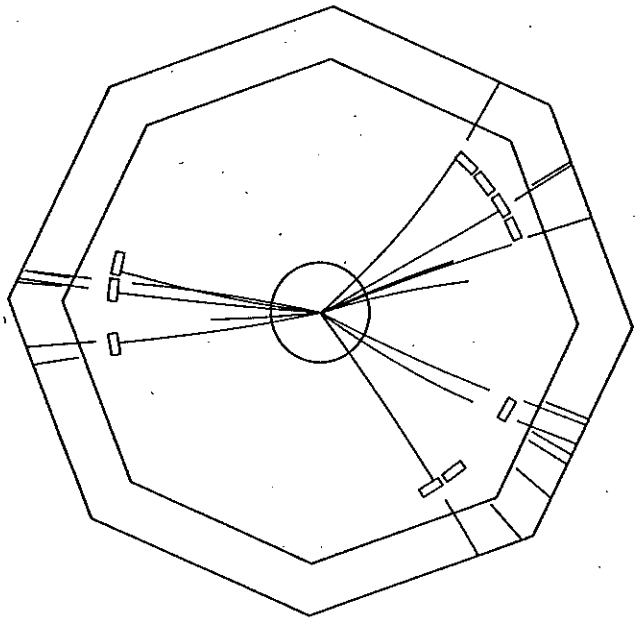


Figure 8.2 A three-jet event. (Courtesy J. Dorfan, SLAC.)

Griffiths

HW problem

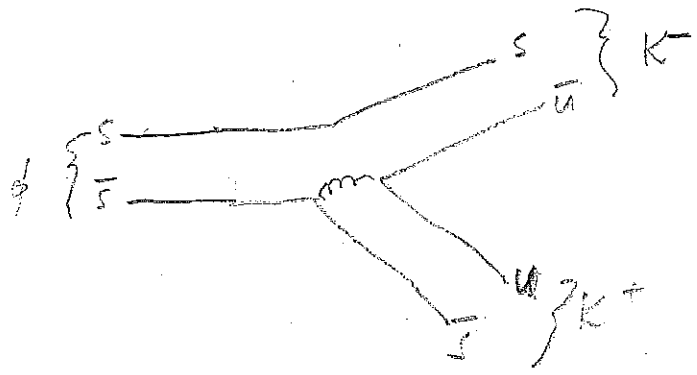
$\phi(1020) = s\bar{s}$

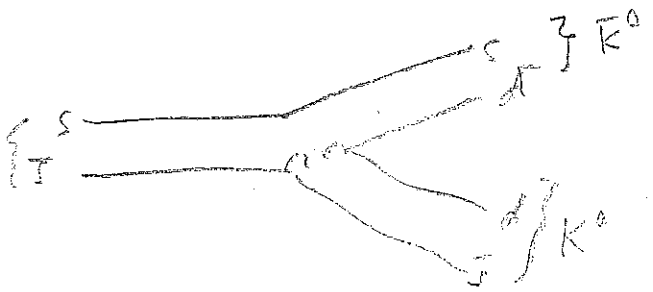
$m = 1020$ MeV

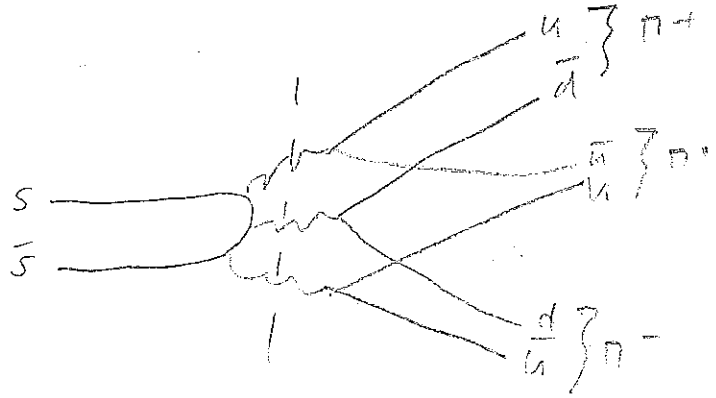
$\tau = 1.5 \times 10^{-22}$ s (strong decay)

	BR	Q
$\phi \longrightarrow K^+K^-$	49%	30 MeV
$\longrightarrow K^0_L K^0_S$	34%	
$\longrightarrow \pi^+\pi^0\pi^-$	15%	600 MeV

$\phi \longrightarrow \pi^+\pi^-$ violates G parity







(OZI suppressed)