Λ (1115)	2.6×10^{-10}s	3×10^{-12}eV		weak
$\Rightarrow N\pi$		3×10^{-12}eV	100%	strangeness (S)
K^+ (494)0^-	1.2×10^{-8}s			weak
$\Rightarrow\pi^+\pi^0$			21.2%	S
$\Rightarrow \mu^+\nu_\mu$			63.5%	S
μ^- (106)$^1/_2$	2.2μs	3×10^{-16}eV		
$\Rightarrow e^-\gamma$		$<10^{-26}$eV	$<5\times10^{-11}$	muon number (L_μ) and electron number (L_e)
$\Rightarrow e^-\nu_\mu\bar{\nu}_e$		3×10^{-16}eV	~100%	weak
η (547)	6×10^{-19}s	1.2 KeV		
$\Rightarrow\pi^+\pi^-$		<2 eV	<0.15%	Parity (P) & CP
$\Rightarrow\pi^+\pi^-\pi^0$		0.3 KeV	23%	EM, G-parity: isospin(I)+C
$\Rightarrow\gamma\gamma$		0.5 KeV	39%	electromagnetic (EM)
$\pi^0\Rightarrow \gamma\gamma\gamma$		2×10^{-7}eV	$<3\times10^{-8}$	$\sim\alpha^3$ charge conjugation (C)
π^+ (140)0^-	2.6×10^{-8}s	2×10^{-8}eV		lightest charged hadron or boson
$\Rightarrow \mu^+\nu_\mu$		2×10^{-8}eV	99.98%	weak
$\Rightarrow e^+\nu_e$		3×10^{-12}eV	1.2×10^{-4}	helicity
K^0_L (498)0^-	5×10^{-8}s	1×10^{-8} eV		
$\Rightarrow\pi^+\pi^-$		3×10^{-11} eV	0.2%	CP
$\Rightarrow\pi^+\pi^-\pi^0$		2×10^{-9} eV	12.6%	

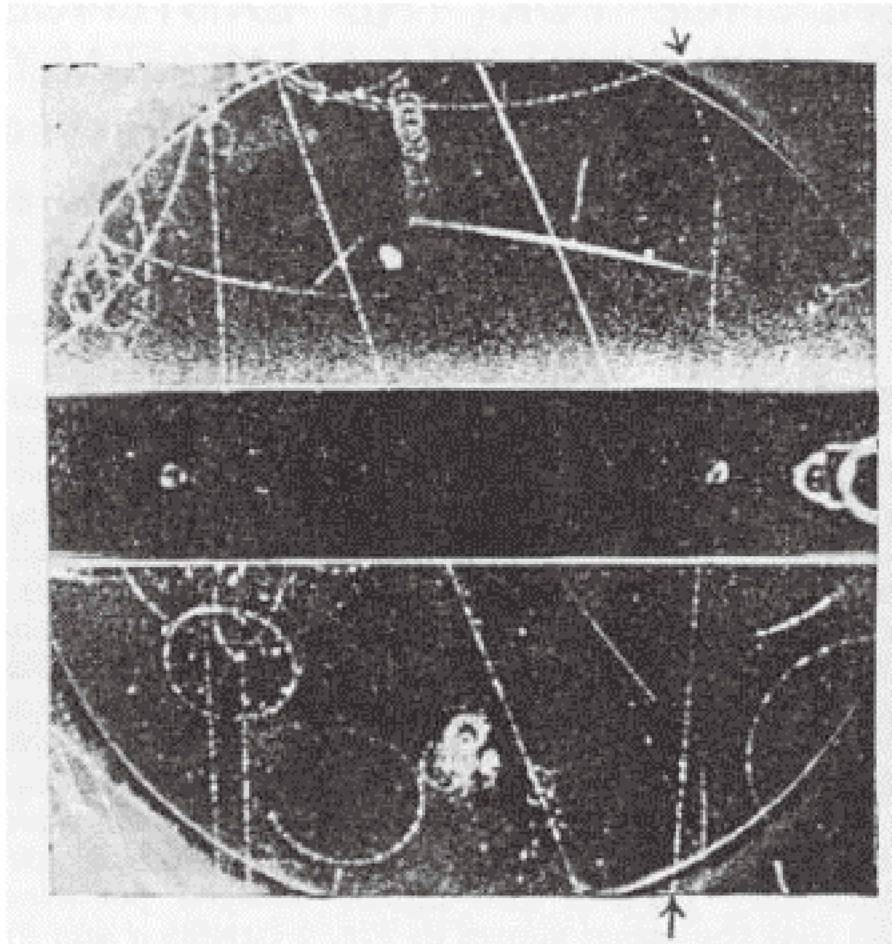
Flavour Conservation Laws

Strangeness (S), muon number (L_μ), and electron number (L_e) are examples of a "flavour" quantum numbers. These conservation laws are simply a reflection of the existence of the fundamental fermions.

quarks: u, d, s, c, b, t

leptons: e, ν_e, μ, ν_μ, τ, ν_t

The strong and electromagnetic interactions conserve the fermion flavours, e.g. the only way to get rid of an electron is to annihilate it with an anti-electron (a positron). Similarly, the only way for strong or electromagnetic interactions to get rid of a strange quark is to annihilate it with an anti-strange quark. In this sense we actually have 12 conservation laws, but some are of little importance (i.e. neutrinos don't interact strongly or electromagnetically) or are obscured by other symmetries.



Weak interactions can transform any "up" type quark (u, c, or t) into any "down" type quark (d, s, b), and vice versa, but "up" or "down" type quarks don't mix among themselves. The relative probabilities depend on the transistion. Similarly, weak interactions probably do not conserve lepton flavours.

Isospin

Isospin symmetry is invariance under the interchange of u and d quarks. In nuclear physics, this corresponds to invariance under the interchange of protons and neutrons. In analogy to the two spin states of a fermion, up quarks (or protons) are considered to be the $I_3=+{}^1/_2$ state, and down quarks (or neutrons) are considered to the the $I_3=-{}^1/_2$ state. Mesons (quark-antiquark hadrons) made from u & d quarks can have isospin 0 or 1; u & d quark baryons (qqq states) can have isopin ${}^1/_2$ or ${}^3/_2$; nuclei can have $I=0, {}^1/_2, 1, {}^3/_2$ …

This symmetry is because u and d quarks have negligible mass compared to their strong binding energies in any hadron. As a result, replacing an up quark with a down quark makes almost no difference. For example, a proton (uud) is essentially the same as a neutron (udd), except for a tiny mass difference (~0.1%) and their electric charges.

Isospin symmetry is an accident, since there is no obvious reason why the up and down quarks should have the masses they do, but it is very powerful in understanding hadronic systems and their interactions. The symmetry is not exact, since u and d quarks do have slightly different masses and very different electric charges.

Isospin (I) is conserved by strong interactions. I_3 is conserved by both strong and electromagnetic interactions, since the net number of u quarks and and the net number d quarks never changes. Isospin is a mixture of u & d flavour symmetry with the consequences of u & d quark mass degeneracy.

Sometimes both isospin invariance and charge conjugation invariance cannot both be true; this consistancy can be parameterized using the G-parity quantum number. G corresponds to making a parity transformation in isospin space giving a factor $(-1)^I$, followed by a C transformation. G is conserved by strong interactions, since both I and C are conserved, but not by weak or electromagnetic interactions.