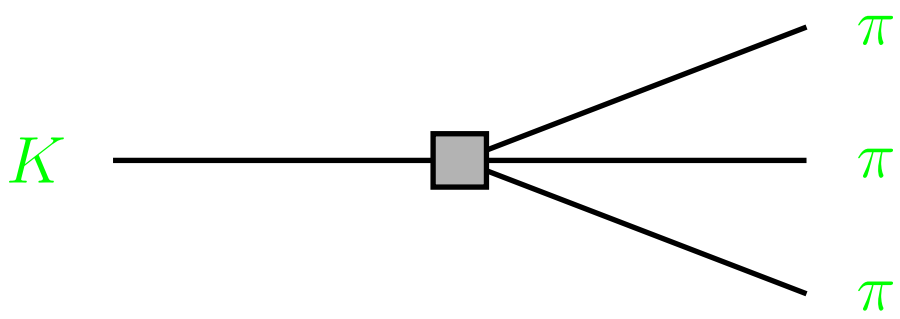
DAΦNE 2004: Physics at Meson Factories

$K \to 3\pi$ Decays in Chiral Perturbation Theory



Fredrik Borg

Theoretical High Energy Physics
Lund University

Introduction to χPT

Aim: To study the physics of hadrons (K, π, η) at low energies (few hundred MeV).

Fundamental Theory: QCD

Problem: Low-energy QCD is non-perturbative, ie. we can't use it to get results.

Solution: Build an Effective Theory.

Effective Lagrangian with the properties:

- Spontaneously broken Chiral symmetry.
- Relevant fields: K, π, η.

$K \to 3\pi$ in the isospin limit

Relevant processes:

$$K^{\pm} \to \pi^{\pm}\pi^0\pi^0$$

$$K^{\pm} \to \pi^{\pm}\pi^{\pm}\pi^{\mp}$$

$$K_L \to \pi^+\pi^-\pi^0$$

$$K_L \to \pi^0\pi^0\pi^0$$

$$K_S \to \pi^+\pi^-\pi^0$$

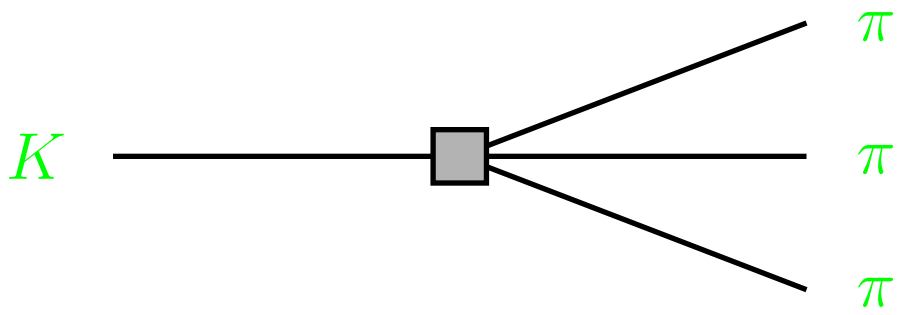
Isospin limit:

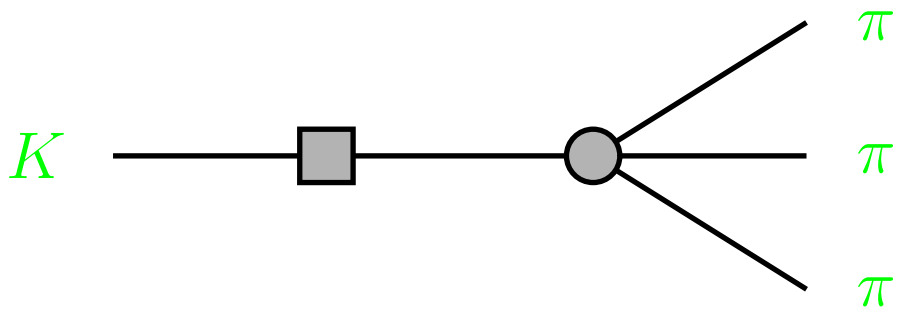
Treating the up- and down-quark as being identical.

$K \to 3\pi$ in the isospin limit

1. Does χPT agree with data?
2. For which values of the free parameters?
3. Conclusions?

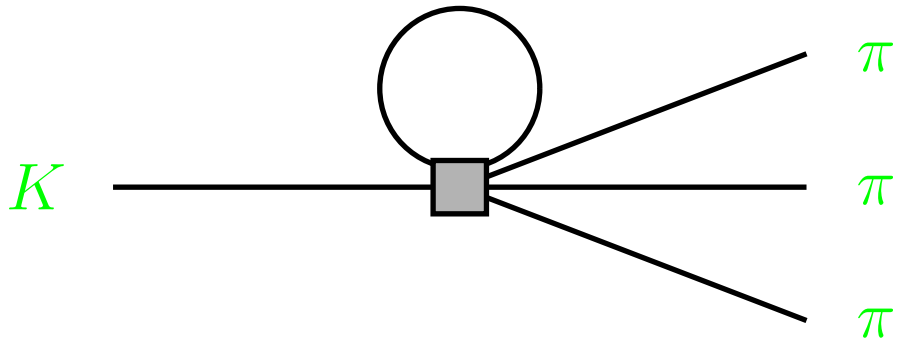
Lowest order (p^2) diagrams:

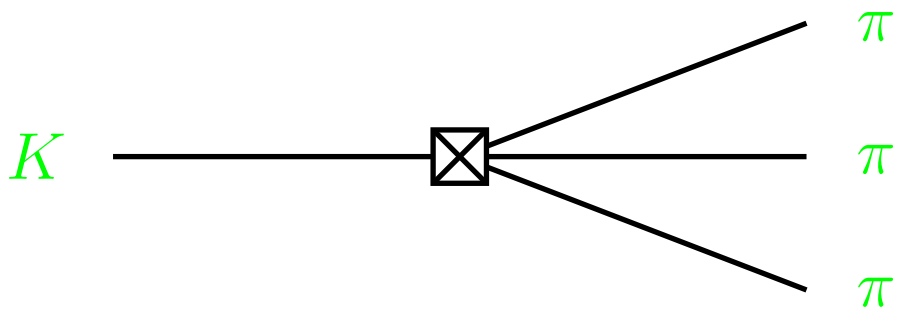




$K \to 3\pi$ in the isospin limit

One-loop order (p^4), 13 new topologies.



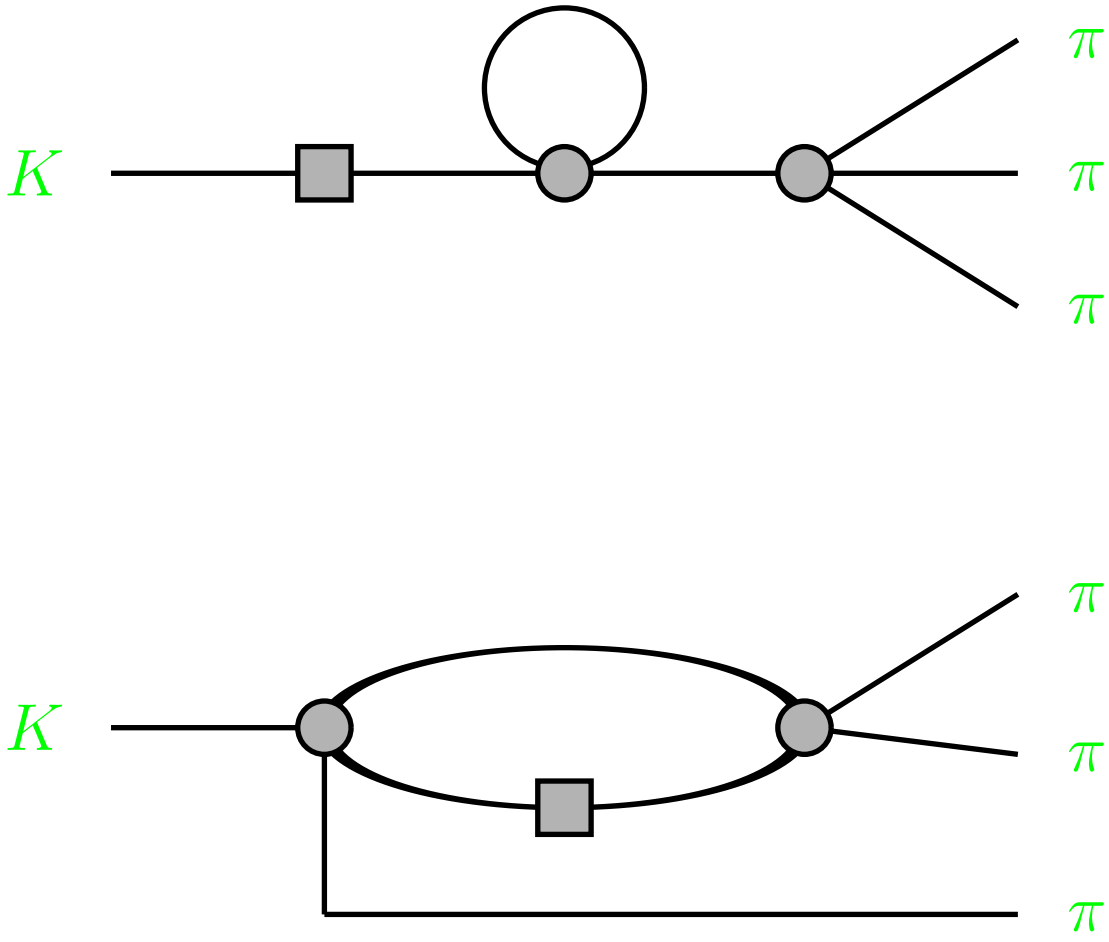


p^2 weak vertex

p^4 weak vertex

$K \to 3\pi$ in the isospin limit

More complicated:



p^2 weak vertex

p^2 strong vertex

Conclusions

- $K \to 3\pi$ tree-level agrees with various published expressions.

Numerical results:

- Fitted χPT parameters reproduce decaywidths and linear slopes.
- Quadratic slopes more difficult. Higher order corrections or isospin breaking effects?

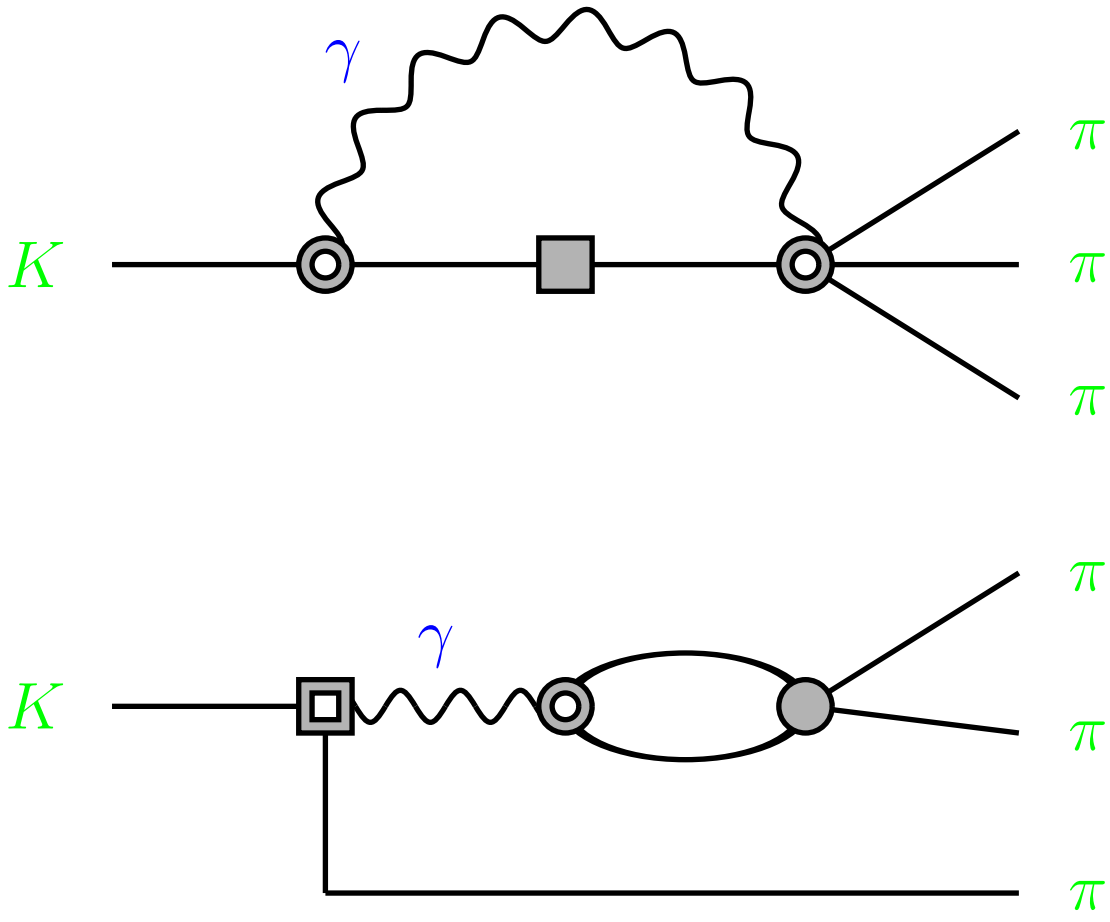
Next step:

- Include isospin violations in the amplitudes.

$K \to 3\pi$ with isospin breaking

Strong isospin breaking:

$m_u \neq m_d \Rightarrow$ Mixing between η and π^0.

Electromagnetic isospin breaking:

EM charges of the quarks $\Rightarrow$ 40 new topologies.