QUESTION Mail:
Dear Prof.Olsen,

I'm Xiaodong from USTC, China, a young graduated student. This summer I was really lucky to have your class at UCAS.

I just have a question about D+ decay to pi0/Ks e+ \nu_e. This is a work at BESIII. And this work has been published: https://journals.aps.org/prd/pdf/10.1103/PhysRevD.96.012002
In this work, they found this three body decay is not in PHSP way, as TABLE IV shown in that paper.
I'm confused, I think neither of two particles in final states can come from a resonance, so why the decay is not PHSP decay?
(When I discussed with my workmates, one of them think it may caused by W in feynman diagram. But the W particle is virtual, so I'm still confused.)

Thanks in advanced!

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Best Wishes,
Xiaodong Shi
University of Science and Technology of China

ANSWER Mail:
Dear Xiaodong

Interesting question.

The D+ meson is a c dbar quark combination. The decay diagram for D+-->K e nu (pi e nu) proceeds via c --> s W+ (c -->d W+) followed by W+-->e nu. At lowest order, the dbar quark is not involved in the diagram (and is called a "spectator.').

The W+ propagator goes like 1/(q^2 + M(W)^2), where q^2 is the e nu invariant mass and, since q^2<<M(W)^2, the W propagator goes like 1/M(W)^2 = constant, as you correctly point out.

But the final state s (or d) quark has to combine with the spectator dbar quark to for the final state Ks (or pi) meson. The probability for this depends upon the the momentum of the s (d) quark, and that in turn depends on q^2. The probability for this is expresses as a "form factor" |f(q^2)|^2, which is not constant.

Also, since the initial state D+ and the final state K (pi) are spin=0, while the e nu come from a W+ and, thus, have spin = 1, the K (pi) and the e nu system must be in a relative P wave. This introduces a factor p(K)^(2L+1)=p(K)^3.

Thus, the K(pi) e nu Dalitz plot deviates from a pure S-wave phase space distribution by a factor of p(K)^3 x |f(q^2)|^2.

Parameterizations for, and measurements of |f(q^2)|^2 are given in PRD 80, 032005 (2009).

I hope this helps,
S. Olsen