PROFESSOR: What is gamma? Well, it seems to have a beta in there, alpha. It's a little unclear what gamma means, so let's try to make sense of it.

Gamma has units of energy, because this term has units of energy, and therefore the other term must have units of energy as well. So gamma has units of energy. And from a unit of energy you could get a time. So tau, you can define it as h over gamma. That has units of time. h bar has units of energy times time, so if you divide by energy, you get units of time.

And what is this number? So this is some time. And it's equal to m over 2 alpha beta h bar. We have this guy.

So the natural thing, of course, is to compare to the time delay associated due to this process that we've been studying. So all the time delay, delta t, was 2 h bar dE-- no, d delta dE. And this is 2 h bar dk dE times d delta dk.

Now, d delta dk, we calculated it up on the blackboard. So this was equal to-- this had been calculated as 1 over beta at resonance. At the resonance, this time delay is calculated above, and it's equal to 1 over beta. This thing is also easily calculated, because this is 1 over dE dk, which is h bar squared k over m. Therefore, what do we get? 2 h bar divided by h bar squared. k, you're at rest so that's alpha over m, m here. And d delta dk is a beta.

So what do we get here? Delta t is 2m over h bar alpha beta. And compare with this one, it's 4 times tau. So h over-- so the end conclusion is that h bar over gamma, which is a time, is tau, which is equal to delta t over 4.

So that's the intuition for the half width. So in the distribution of this scattering amplitude, there's a half width. It's an energy distribution. And there's a time associated with it, which is h bar over the half width. And, being a time, it must be related to some physical time that has a period, and there's nothing else than the delay. So if the delay is large, gamma is small, and the width is small. It's a narrow resonance. So a narrow resonance is one in which the width is very small.

So this has enormous applications. It's used in nuclear physics all the time. It's used in particle physics as well. The Higgs-Boson was discovered over a year ago, it's a particle but it's unstable. It decays very fast. If you thought in terms of that, it just gets created by a reaction, stays in the well for a little while, and poof, disappears. So its mathematics in cross-sections is governed by resonances.

So we call the Higgs particle a particle, but anything that is unstable it's more like, more precisely viewed as an object that represents a resonance. The Higgs particle doesn't live too long. Lives about 10 to the minus 22 seconds. Very little time. And then it decays and it goes into b-bbar, bottom bottom bar quark. As it goes into z's, it goes into tau lambda. So it goes into two photons. It can decay into all these things.

So in the case of the Higgs-Boson, the center energy of the resonance is observed in scattering amplitudes at a center energy E alpha of 125 GEv. The width is very small. In fact, the width is about gamma, it's about 4 MEv plus minus 5%. 4 MEv, that's very little, because an MEv is 1/1000 of a GEv. So it's a very narrow resonance.

And from this gamma, you can get a time. And the time is lifetime. It's about 10 to the minus 22 seconds.

So this is the language that we use to describe any unstable particle. We think of it as resonance. It's sometimes called resonance. And the title of papers that appear at that time is the resonance observed in the data, the Higgs-Boson. And the answer was yes. This was observed as a resonance. It is a scattering amplitude that is uniform, and it has some energy, has a little peak.

You can imagine people can't quite measure the width directly. It's too narrow. So the plots don't show the width, but the width is implied, and there's related calculations over here with the lambda. So it's all a nice story.

OK. So look what we've done. We began by discussing that we could not get time delays that were negative. Times advance, then we get long time delays, and that's a resonance. We showed that they correspond to changes, rapid changes of delta in the positive direction. And we've modeled them so that in general, we have a general description of what's happening near a resonance.