MARKUS KLUTE: Welcome back to 8.20, Special Relativity. In this section, we want to study the decay of a particle, in this case, the decay of a pion. The pion is a particle which consists of quarks and antiquarks, which are bound together by gluons. They're part of a family of particles which are called mesons.

And they can be charged and neutral. So we have positively-charged, negatively-charged, and neutral pions. In this example, we look at a neutral pion decay and the specific decay into an electron and a positron. Mostly, neutral pions and decay into a pair of photons. But we study this effect here because it's more fun.

The lifetime or the mean lifetime over pi 0 is 8 times 10 to the minus 17 seconds. So when we produce neutral pions in our detector, they immediately decay, as I said, mostly into a pair of photons. That we discovered in the 1940s.

So let's get to it. So the mass of a pion-- of neutral pion is 135 MeV. So it's much heavier than an electron, which is 500-- has a mass of 511 KeV. So we're looking at this decay here.

We have a pion a rest into an electron and a positron. And so the charge for you now is to find the gamma factor of the electron or the positron or, [? with ?] that, the velocity of those particles and the decay of a pion at rest. So again, as usual, stop the video, and try to work this out.

And again, what we want to do is just write down the four-vector of the particles involved. We start with the pion, which has an energy of the pion mass times c square. And it's at rest in this example here, which means that the momentum is 0. And so then the outgoing particles are the electron and positron with their energy and their momentum.

And then just from this first line here from the energy relation, you can-- by knowing that the mass of the electron and a positron are the same, by knowing that the gamma factor is the same that comes out of the momentum relation here, that they have the same velocity, you can just simply find gamma as equal to the pion mass divided by 2 times the electron mass. And that is about 132.

So again, we studied the decay of a pion. And as a general example of the decay of a particle into two new particles, we used the energy momentum relation. We make sure use of the [? effect, ?] in this case, that we are in the rest frame of the pion. And then we are able to get to the velocity or the gamma factor of the outgoing particles.