Muon escape.
(What is the reason for detecting cosmic muons on *Earth*?)

The *intensity* of *events* and *event concentration* are characteristics of the systems of reference. Their value depends on the status of the system of reference. The *intensity of events* and the *event concentration* for the system of reference at theoretically genuine rest are $\varepsilon=1$ and $z=1$. The *intensity of events* and the *event concentration* of the system of reference in motion with the speed of light is *zero*. For any other status of systems of reference the values of the *intensity* and *event concentration* are between these two endpoints.

The question is how can cosmic muons, having been generated at a distance of *10-20 km* above the surface, make it to the *Earth*, when their half-life time is *2-2.5 μsec*? (Even light makes only *750 m* for *2.5 μsec*.)

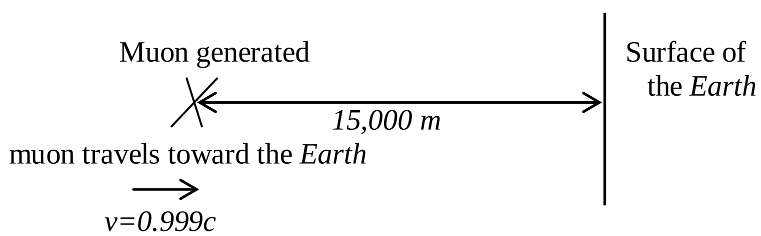
This is a single *event* simultaneously happening within two systems of reference:
- in the system of reference of Earth; and
- in the system of reference of the muon.

The event must be examined from the point of view of these two systems of reference.

These are the inputs:
$s=15{,}000\ m$, the distance of the muon generation, taken and measured from the surface of *Earth*;
$\Delta t_E=2.25\ \mu sec$, measured on the surface of *Earth*;
$v=0.999c\ m/sec$, the uniform speed of the muon,
$c = 3\cdot 10^8$ m/sec, the speed of light.

There are three points to note here:
- the event is one and the same and occurs simultaneously in the *two* systems of reference;
- the relative speed between the two systems of reference is $v=0.999c$, one and the same value from the point of view of both systems of reference;
- the distance between the spot where the muon was generated and the surface of the *Earth* can be measured as being of different lengths from the point of view of the two systems of reference.

The event, from the point of view of the *Earth's* system of reference, is presented in the figure:



There will be 2 cases to examine.

Case 1:
Earth is the stationary system of reference and the system of reference of the muon is the one in motion.

The *2-2.5 μsec* duration of the half-life of the muon is a laboratory result, measured on the surface of Earth, taken in this example as $\Delta t_E = 2.25\ \mu sec$.

Motion modifies and speeds up the time flow, consequently, the half-life time of the muon from the point of view of its own system of reference, in motion with *v=0.999c* relative to the *Earth*, is

$$\Delta t_{muon} = \frac{\Delta t_E}{\sqrt{1 - \frac{(0.999c)^2}{c^2}}};$$

From A1 it follows that the half-life time of the muon in its own system of reference is $\Delta t_{muon} = 50.3 \mu \sec$

For this time period, which is counted within the system of reference of the muon, the muon makes *15,100 m*, and reaches the surface of the *Earth* for the duration of a half-life to be detected. Should the speed of the muon relative to the *Earth* be taken too optimistically and it were only *0.99c*, even in that case the muon would reach the *Earth's* surface for its four half-lives to be detected. In this case the half-life of the muon, from the point of view of its own system of reference, would be 15.9 *μsec.* (For the simplicity of the example we will take the speed of the muon as 0.999c.)

The appearance of the length, the muon travels, based on the muon's half-life time, measured within the frame of the system of reference of the *Earth* is:

$$l_E = \Delta t_E \cdot v = 2.25 \cdot 10^{-6} \cdot 0.999c = 674m$$

The appearance of the length, the distance the muon makes from the point of view of its own system of reference is:

$$l_m = \Delta t_m \cdot v = 50.3 \cdot 10^{-6} \cdot 0.999c = 15{,}100m$$

With reference to A.2 and A.3 we have for the same absolute distance *two* measured results, the reason of which is the difference in the time systems of the two examined systems of reference.

Taking the event concentration on the *Earth* equal to $z_E = 1$, the event concentration at the muon is:

$$z_m = \frac{\varepsilon_m}{\varepsilon_E} = \frac{dt_E}{dt_m}; \qquad z_m = 4.471018 \cdot 10^{-2}$$

The measured distance within the system of reference of the muon, corrected by the event concentration, corresponds to the length, measured within the supposed to be stationary system of reference of the *Earth*:

$$L_m = z_m l_m = 4.471018 \cdot 10^{-2} \cdot 15{,}100 = 674m$$

since $L_E = z_E l_E = 1 \cdot 674 = 674m$

and obviously $L_m = L_E$

The conclusion is that the muon certainly reaches the surface of the *Earth*. While the spot of the generation of the muon is at a distance of *15.1 km* above the surface of the *Earth*, its appearance on the *Earth*, as a path travelled by the muon with speed of 0.999c, is just *674 m*.

Case 2:
As equal parts of a relation, the muon is taken now as the stationary system of reference. From the point of view of the system of reference of the muon in this case the "*Earth* is in motion with *v=0.999c* toward the muon".

The "laboratory results at the muon" prove that the event happens for $\Delta t_{muon} = 50.3\mu\sec$. (This is the measurement within the system of reference of the muon, as identified in the earlier case. The muon is not aware of its motion and relies on the de facto measurements within its system of reference.)

The *Earth,* as the experiment on the muon shows, makes the $l_m = 15$ km for this $\Delta t_{muon} = 50.3\mu\sec$ time period, and there are no more questions.

The distance however the *Earth* has to make to reach the muon, measured within the system of reference of the *Earth*, being in motion with 0.999c relative to the muon's system of reference, is $l_E = 335$ km. While "the *Earth* is generated" at a known distance of 15.1 km from the muon and certainly reaches it, this distance on the *Earth*, in motion relative to the muon, would be measured in accordance with its supposed speed and time system:

from $$l_E = \frac{l_m}{\sqrt{1-\frac{(0.999c)^2}{c^2}}} = 335$$ and $l_m = 15$ km

How can the *Earth* make 335 km for $50.3\mu\sec$? (We suppose that we are aware of the measurements made on the muon.)

The event, in this supposed case on the surface of *Earth,* would happen for

$$\Delta t_E = \frac{\Delta t_m}{\sqrt{1-\frac{(0.999c)^2}{c^2}}} \qquad \Delta t_E = 1.130 \text{ msec}$$

The distance *Earth* makes for this time period measured within the system of reference of the *Earth* is:

$$l_{E(measured)} = \Delta t_{E(measured)} \cdot c = 1.13 \cdot 10^{-3} \cdot 0.999c = 337 \text{ km}$$

Since the event concentration between the two systems of reference is:

$$z_E = \frac{\varepsilon_E}{\varepsilon_m} = \frac{dt_m}{dt_E}; \quad z_E = 4.471018 \cdot 10^{-2}$$

and the distance measured at the muon is $L_m = 15$ km,

the corrected by the event concentration distance, measured on the surface of the *Earth* is:

$$L_E = z_E \cdot l_{E(measured)} = 15 \text{ km}$$

While the spot of the "generation of the *Earth*" is at a distance of *15.1 km* from the muon, the appearance of this distance on the *Earth*, "supposed to be in motion relative to the stationary muon", as the path to be travelled by the *Earth* with speed of 0.999c, is *337km*.

The reason of the difference in the measured values of the same de facto distance is the appearance of the event in systems of reference, different in their status of motion and the technique of the calculation.