



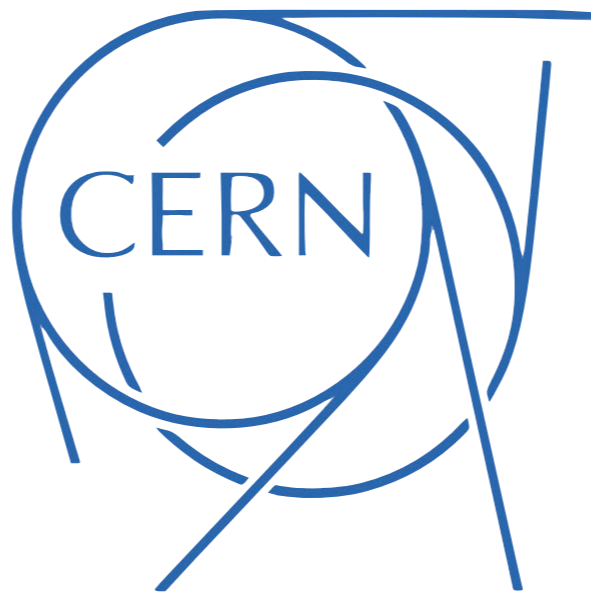
Cloud Chamber Workshop

Konrad Jende, Estonian Teachers Programme 2015

Artistic view of a cosmic rays shower.

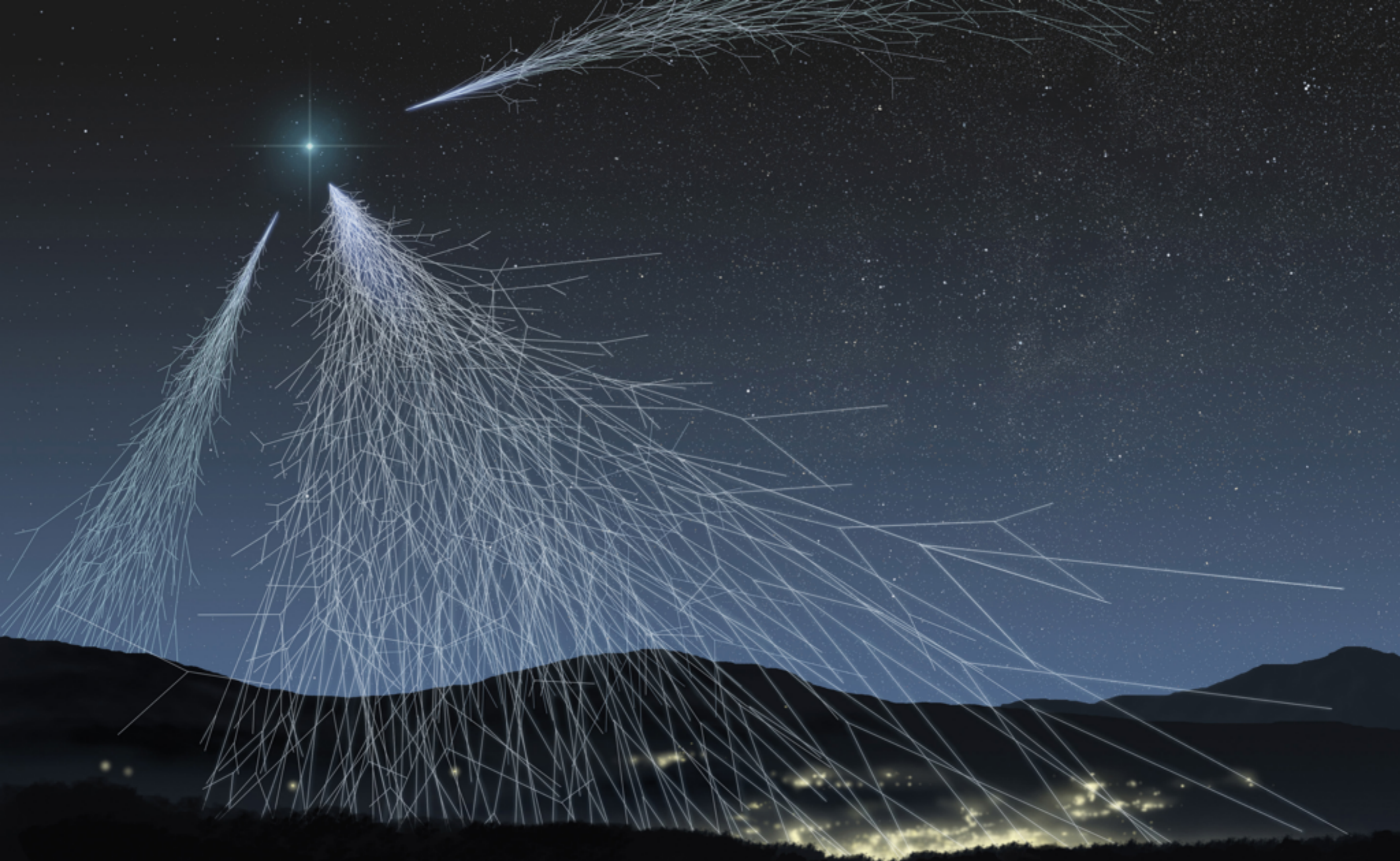
Credit: ASPERA/Novapix/L.Bret

Source: http://www.aspera-eu.org/index.php?option=com_content&task=view&id=290&Itemid=196



Cloud Chamber Workshop

Konrad Jende, Estonian Teachers Programme 2015



Artistic view of a cosmic rays shower.

Credit: ASPERA/Novapix/L.Bret

Source: http://www.aspera-eu.org/index.php?option=com_content&task=view&id=290&Itemid=196

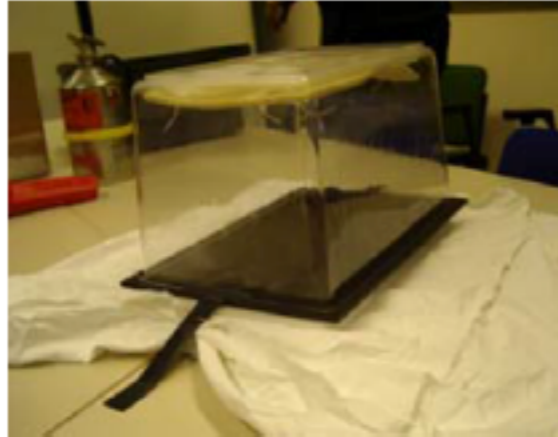
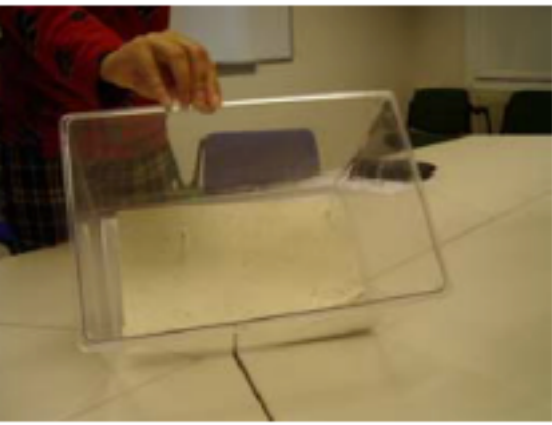
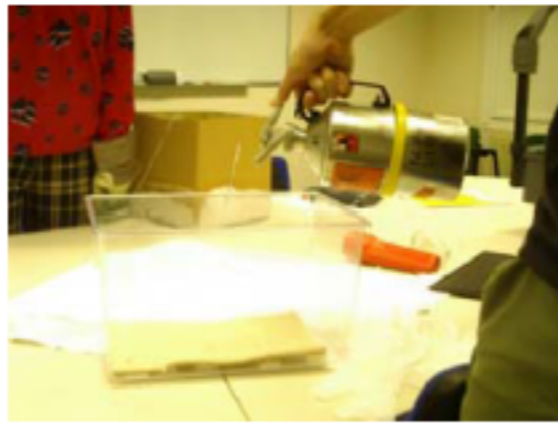
Outline

1. Instructions
2. Build your cloud chamber
3. Observation 1 and 2
4. Explanations & Discussion
5. Observation 3
6. Another chamber ...

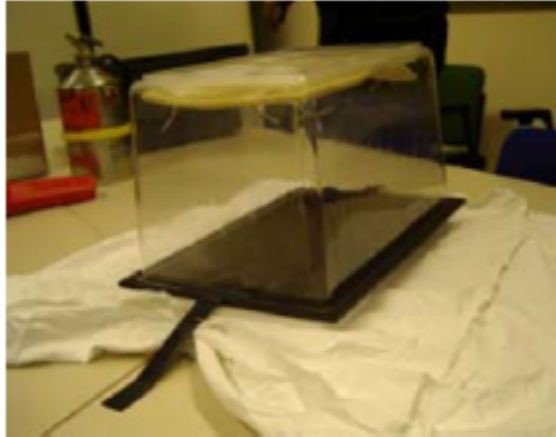
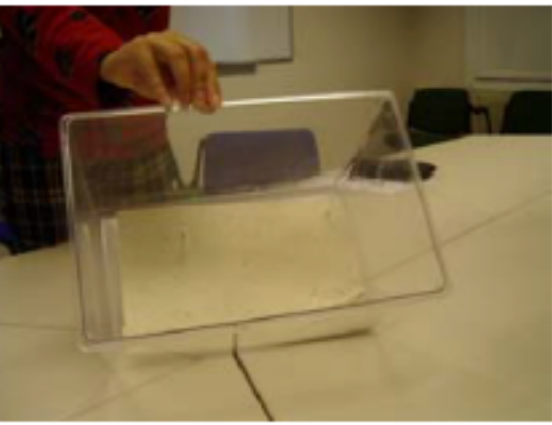
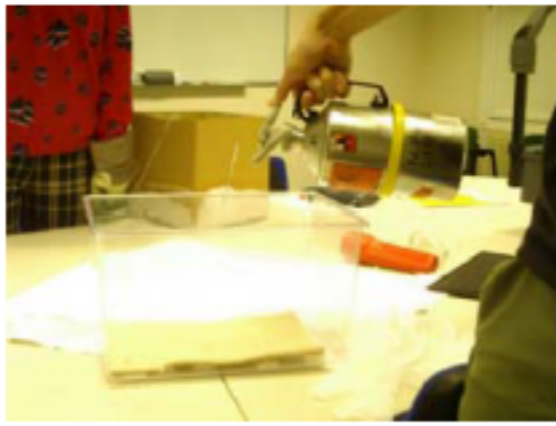
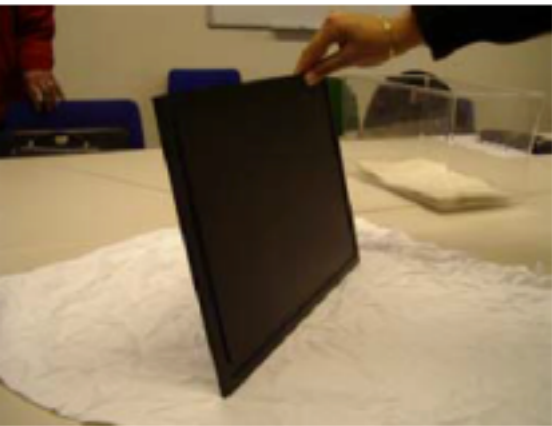
1. Instructions

Shopping List

- A clear, see-through box-like plastic container, with flat sides and an open top, roughly 20 x 30cm (open side) x 15cm (height)
- A metal plate (at least 5mm thick) to cover the open size of the container completely (plate must be a little bit larger than the box). The plate should be preferably black and should have a little grooves matching the side walls of the plastic box. As this is probably hard to find, you can also use a flat metal plate and use black electrical tape to make the metal plate surface black.
- A thick felt (few mm), a bit smaller than the bottom of the box.
4 clips (self-adhesive cable-tie holders + cable ties) to attach the felt to the inside of the bottom of the box
- A small wooden box that is just a little bit larger in area than the metal plate and approx. 5cm in height. The box later on has to take the ice plates and the metal plate but the sides should not be much higher so that it doesn't cover the plastic box.
- A very intense, bundled light source, e.g. a slide projector, strong flashlight ...
- Pure (not 70%) isopropyl alcohol – make sure you get the right one – it will only work well with this one it and keep it out of reach of children).
- Dry Ice (Careful with your hands – always use thick gloves and never touch the ice directly! The ice is at -78°C ; touching it directly will give you a burn.)
- Security goggles to handle the ice
Gloves to handle the ice and the alcohol



2. Build your cloud chamber



Shopping List

- A clear, see-through box-like plastic container, with flat sides and an open top, roughly 20 x 30cm (open side) x 15cm (height)
- A metal plate (at least 5mm thick) to cover the open size of the container completely (plate must be a little bit larger than the box). The plate should be preferably black and should have a little grooves matching the side walls of the plastic box. As this is probably hard to find, you can also use a flat metal plate and use black electrical tape to make the metal plate surface black.
- A thick felt (few mm), a bit smaller than the bottom of the box.
4 clips (self-adhesive cable-tie holders + cable ties) to attach the felt to the inside of the bottom of the box
- A small wooden box that is just a little bit larger in area than the metal plate and approx. 5cm in height. The box later on has to take the ice plates and the metal plate but the sides should not be much higher so that it doesn't cover the plastic box.
- A very intense, bundled light source, e.g. a slide projector, strong flashlight ...
- Pure (not 70%) isopropyl alcohol – make sure you get the right one – it will only work well with this one it and keep it out of reach of children).
- Dry Ice (Careful with your hands – always use thick gloves and never touch the ice directly! The ice is at -78°C ; touching it directly will give you a burn.)
- Security goggles to handle the ice
Gloves to handle the ice and the alcohol

3. Observations 1 and 2

Tasks:

Observe with your cloud chamber.

Describe what you observe.

4. Explanations/Discussion

Please come to the whiteboard to discuss both the functioning of the chamber and possible sources of particles.

Air Shower Simulation

blue:electrons/positrons

cyan:photons

red:neutrons

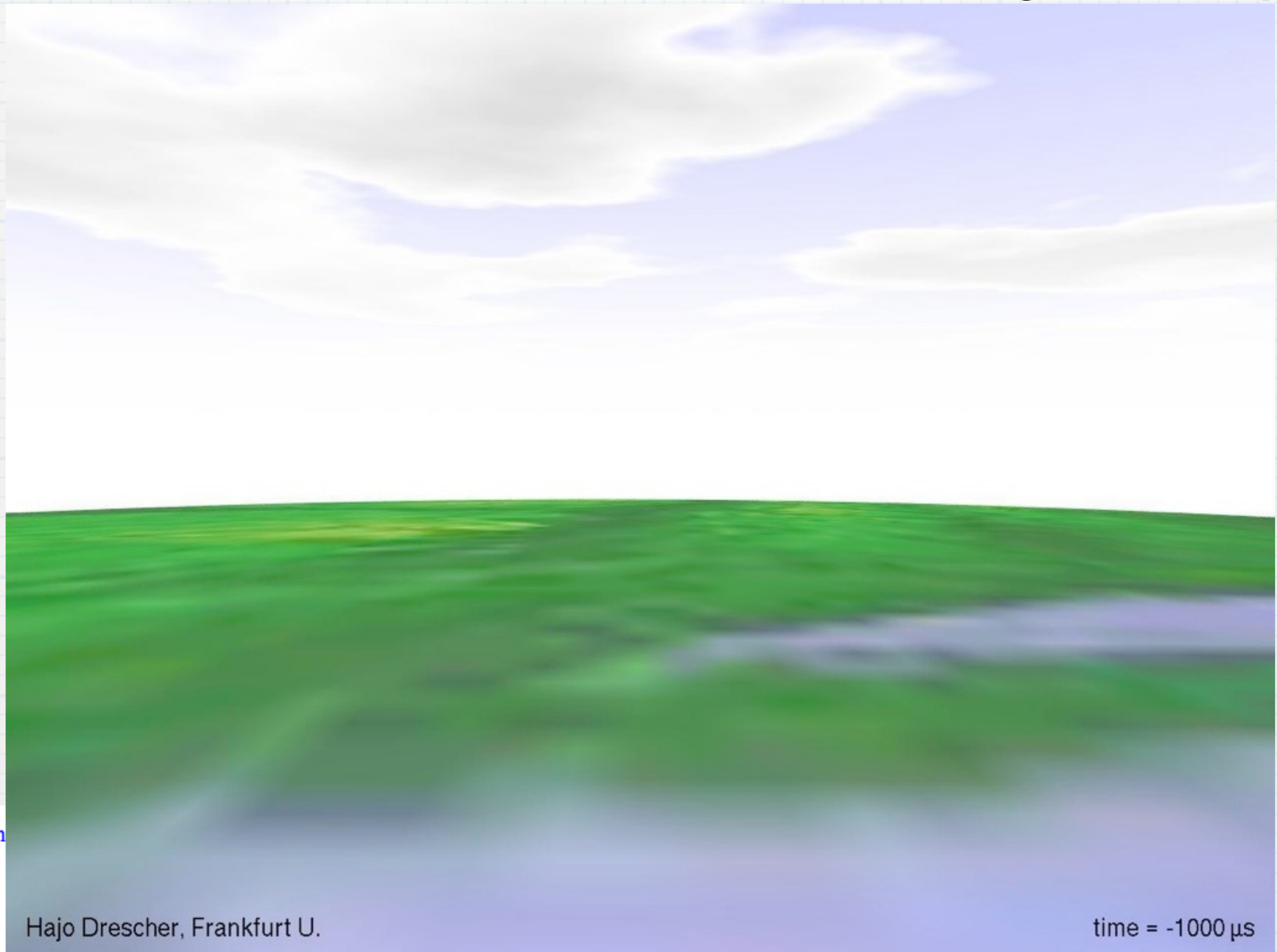
orange: protons

gray: mesons

green:muons

3. Die Teilchen dieser Welt und ihre Eigenschaften

I. Die endliche Lebensdauer von Teilchen - ein alltägliches Beispiel



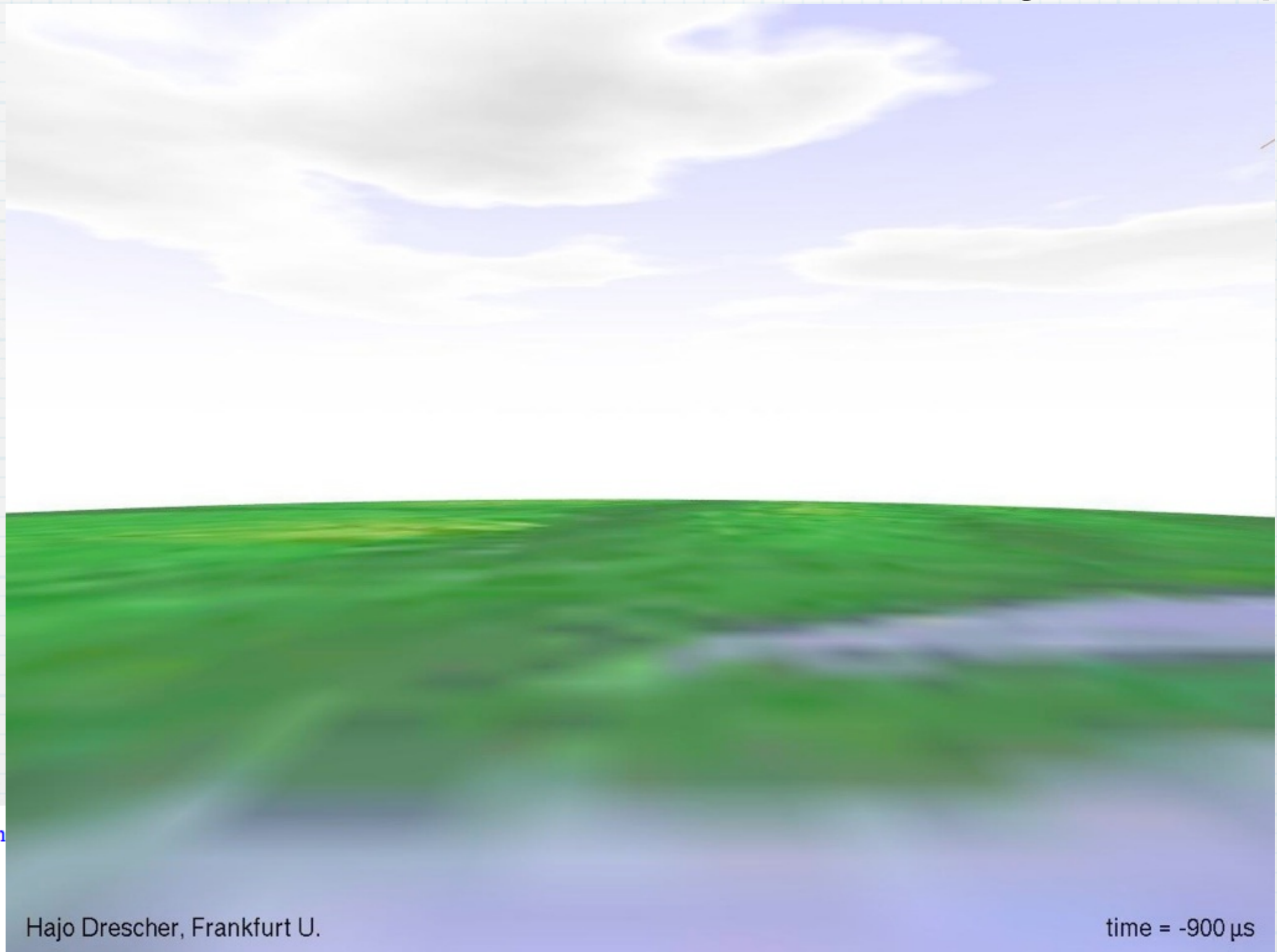
blue:electrons/positron
cyan:photons
red:neutrons
orange: protons
gray: mesons
green:muons

Hajo Drescher, Frankfurt U.

time = -1000 μ s

3. Die Teilchen dieser Welt und ihre Eigenschaften

I. Die endliche Lebensdauer von Teilchen - ein alltägliches Beispiel



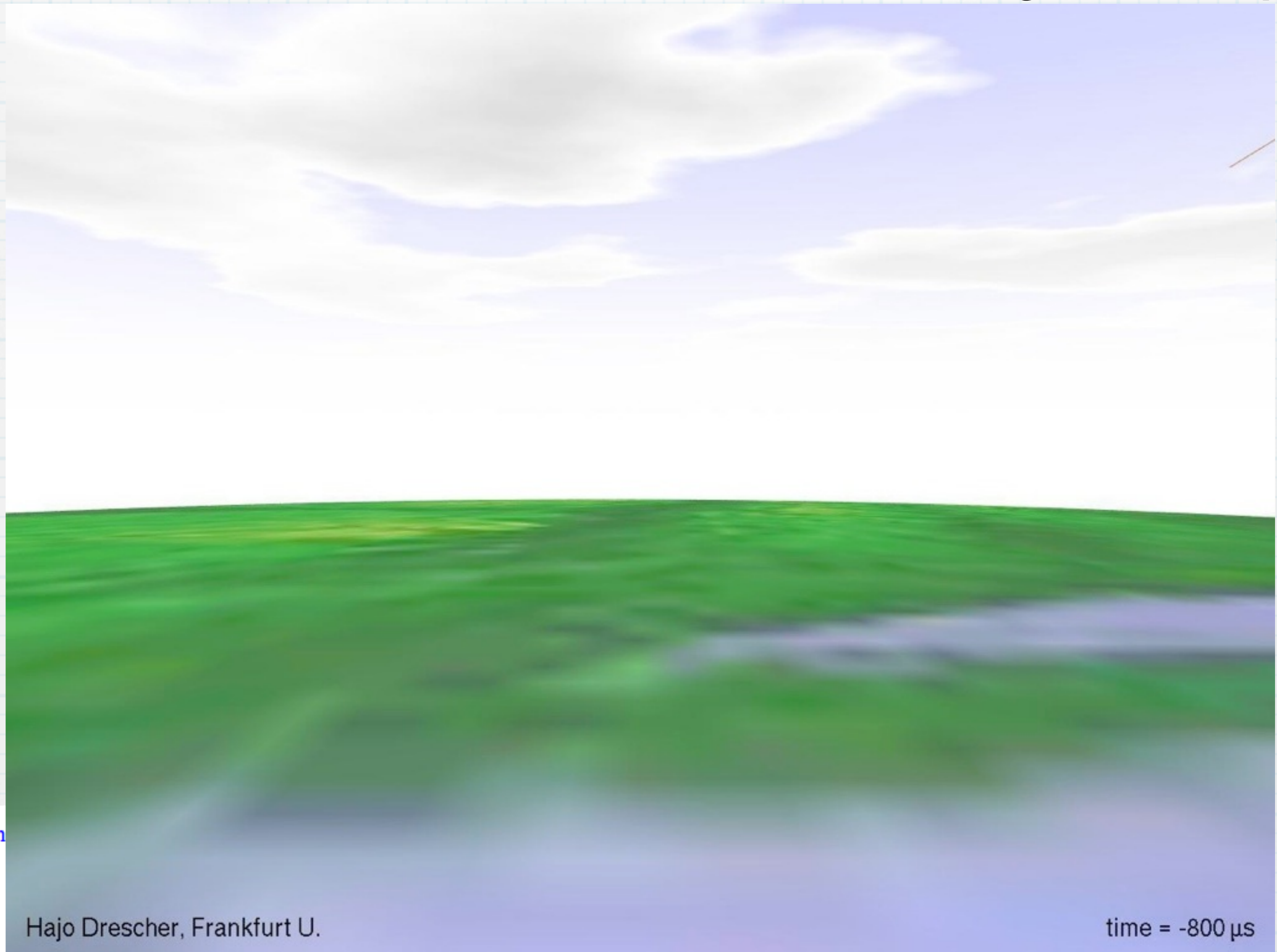
blue:electrons/positron
cyan:photons
red:neutrons
orange: protons
gray: mesons
green:muons

Hajo Drescher, Frankfurt U.

time = -900 μ s

3. Die Teilchen dieser Welt und ihre Eigenschaften

I. Die endliche Lebensdauer von Teilchen - ein alltägliches Beispiel



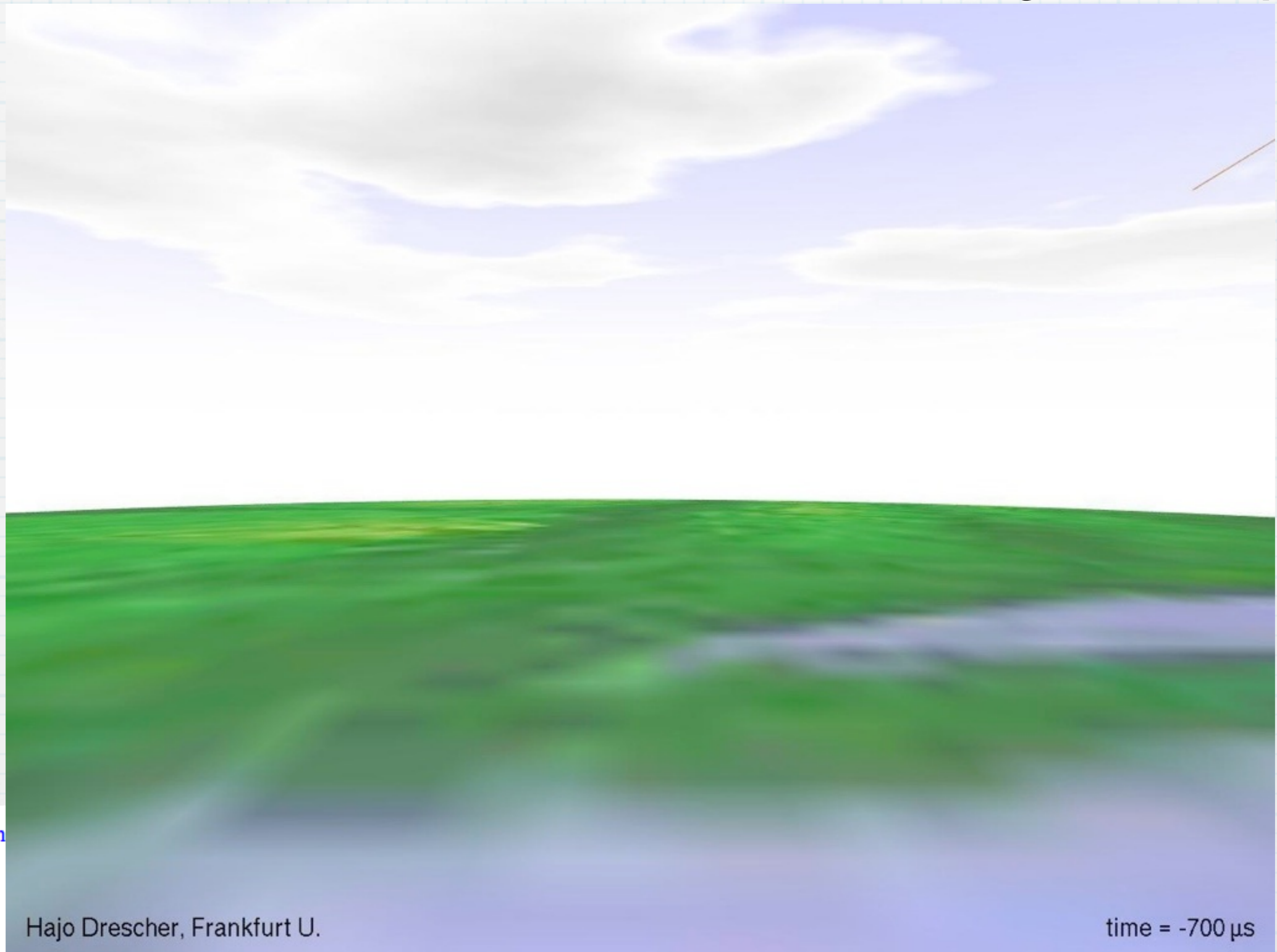
blue:electrons/positron
cyan:photons
red:neutrons
orange: protons
gray: mesons
green:muons

Hajo Drescher, Frankfurt U.

time = -800 μ s

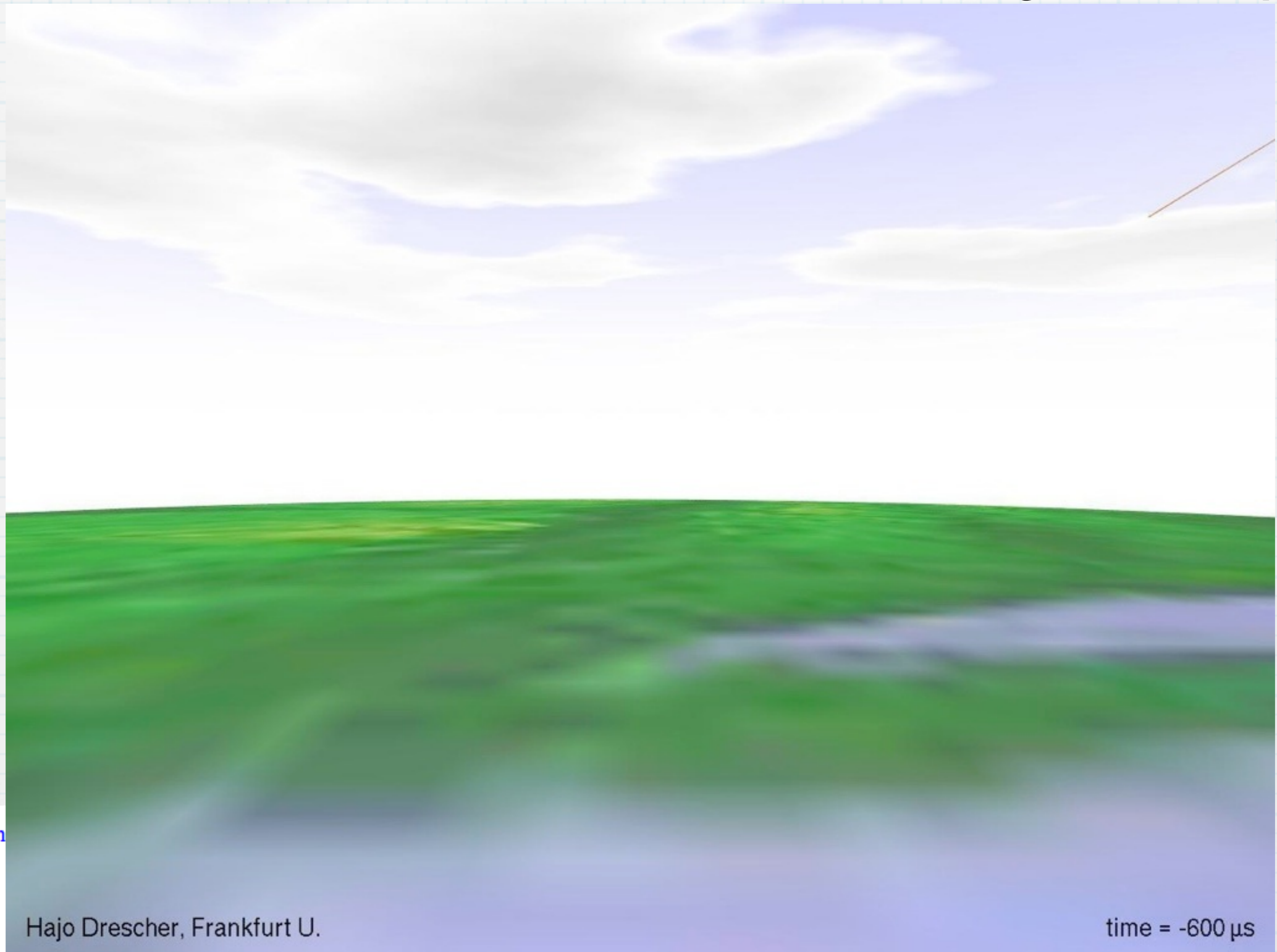
3. Die Teilchen dieser Welt und ihre Eigenschaften

I. Die endliche Lebensdauer von Teilchen - ein alltägliches Beispiel



3. Die Teilchen dieser Welt und ihre Eigenschaften

I. Die endliche Lebensdauer von Teilchen - ein alltägliches Beispiel



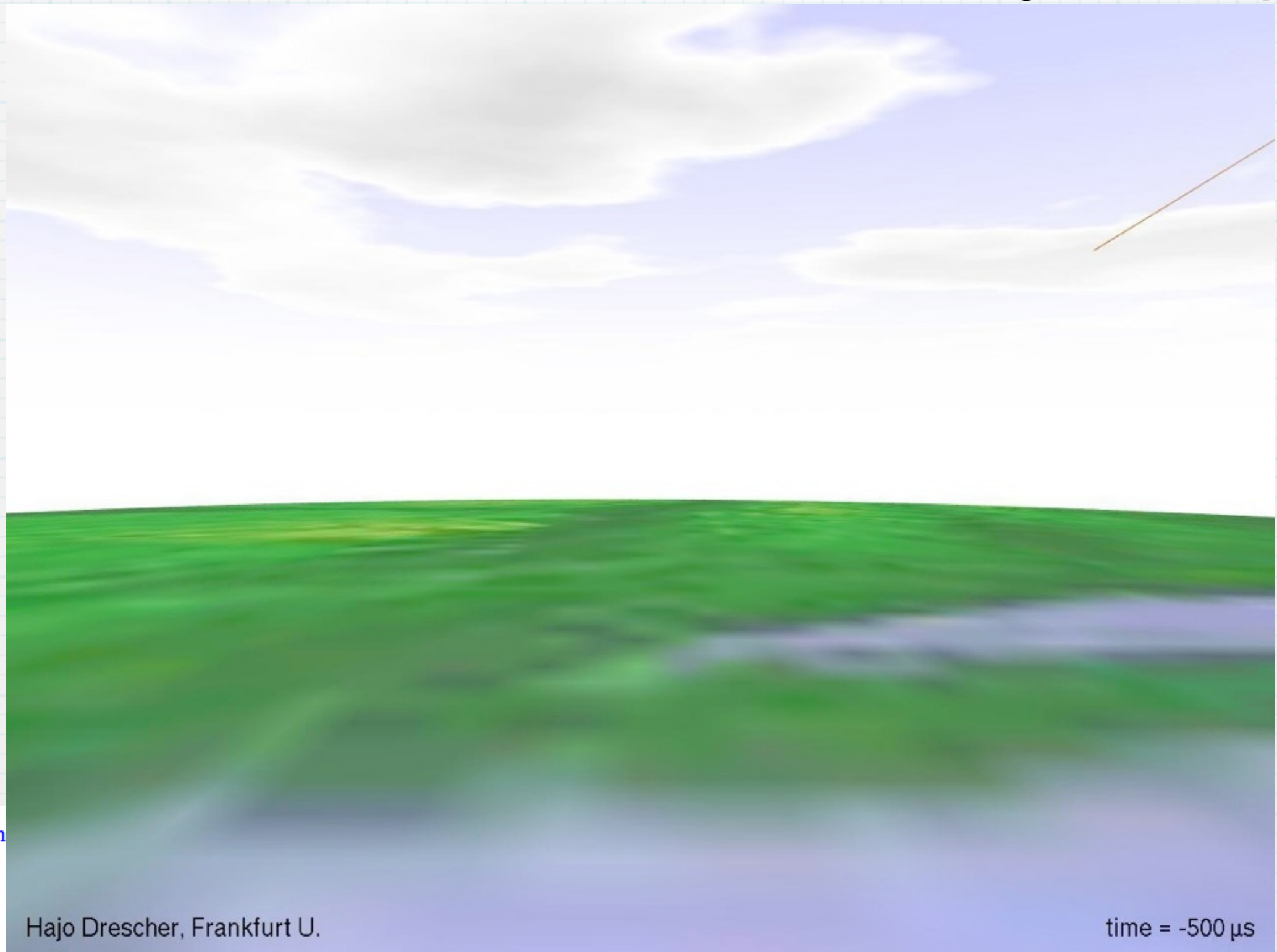
blue:electrons/positron
cyan:photons
red:neutrons
orange: protons
gray: mesons
green:muons

Hajo Drescher, Frankfurt U.

time = -600 μ s

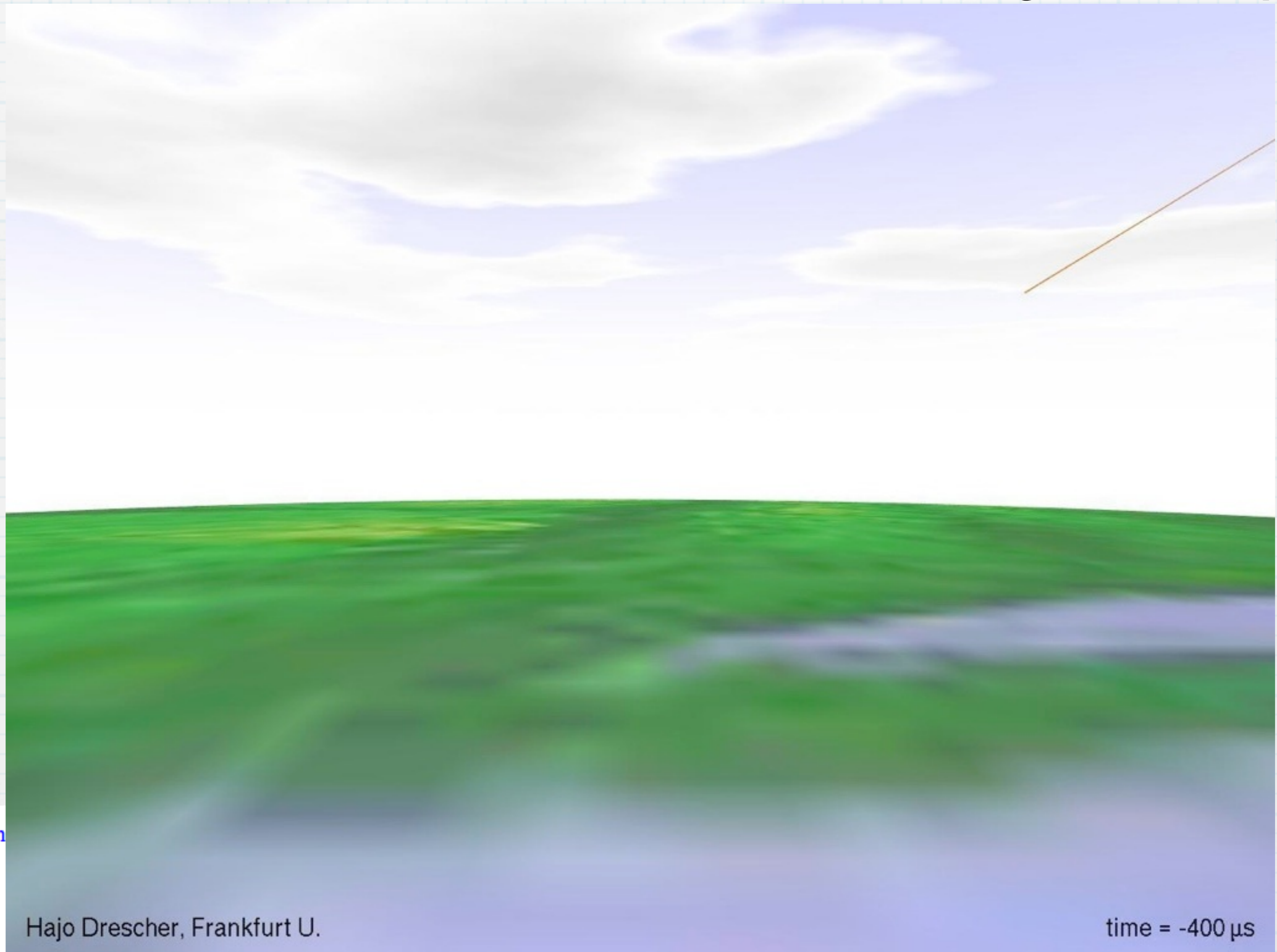
3. Die Teilchen dieser Welt und ihre Eigenschaften

I. Die endliche Lebensdauer von Teilchen - ein alltägliches Beispiel



3. Die Teilchen dieser Welt und ihre Eigenschaften

I. Die endliche Lebensdauer von Teilchen - ein alltägliches Beispiel



blue:electrons/positron
cyan:photons
red:neutrons
orange: protons
gray: mesons
green:muons

Hajo Drescher, Frankfurt U.

time = -400 μ s

3. Die Teilchen dieser Welt und ihre Eigenschaften

I. Die endliche Lebensdauer von Teilchen - ein alltägliches Beispiel



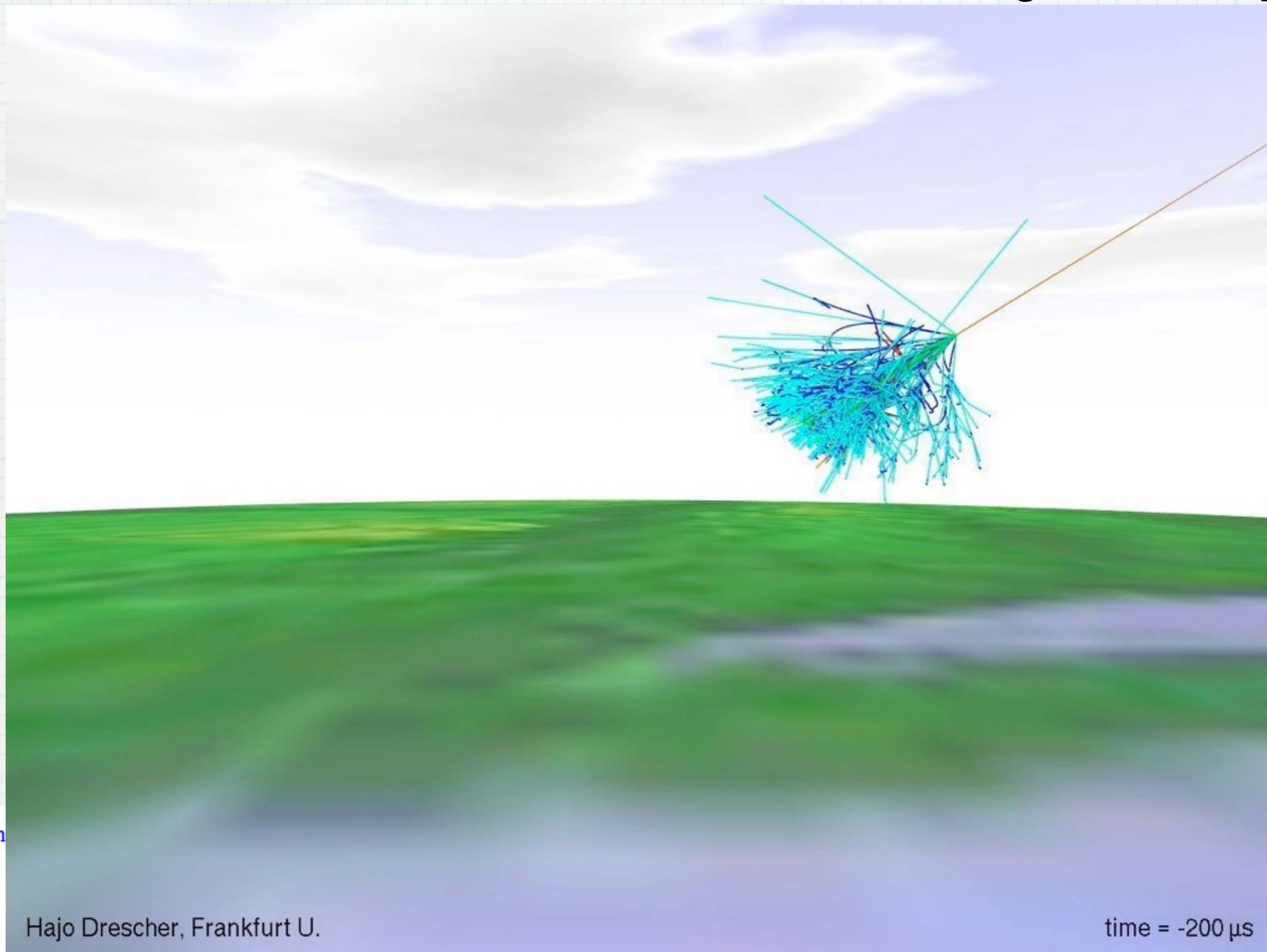
blue:electrons/positron
cyan:photons
red:neutrons
orange: protons
gray: mesons
green:muons

Hajo Drescher, Frankfurt U.

time = -300 μ s

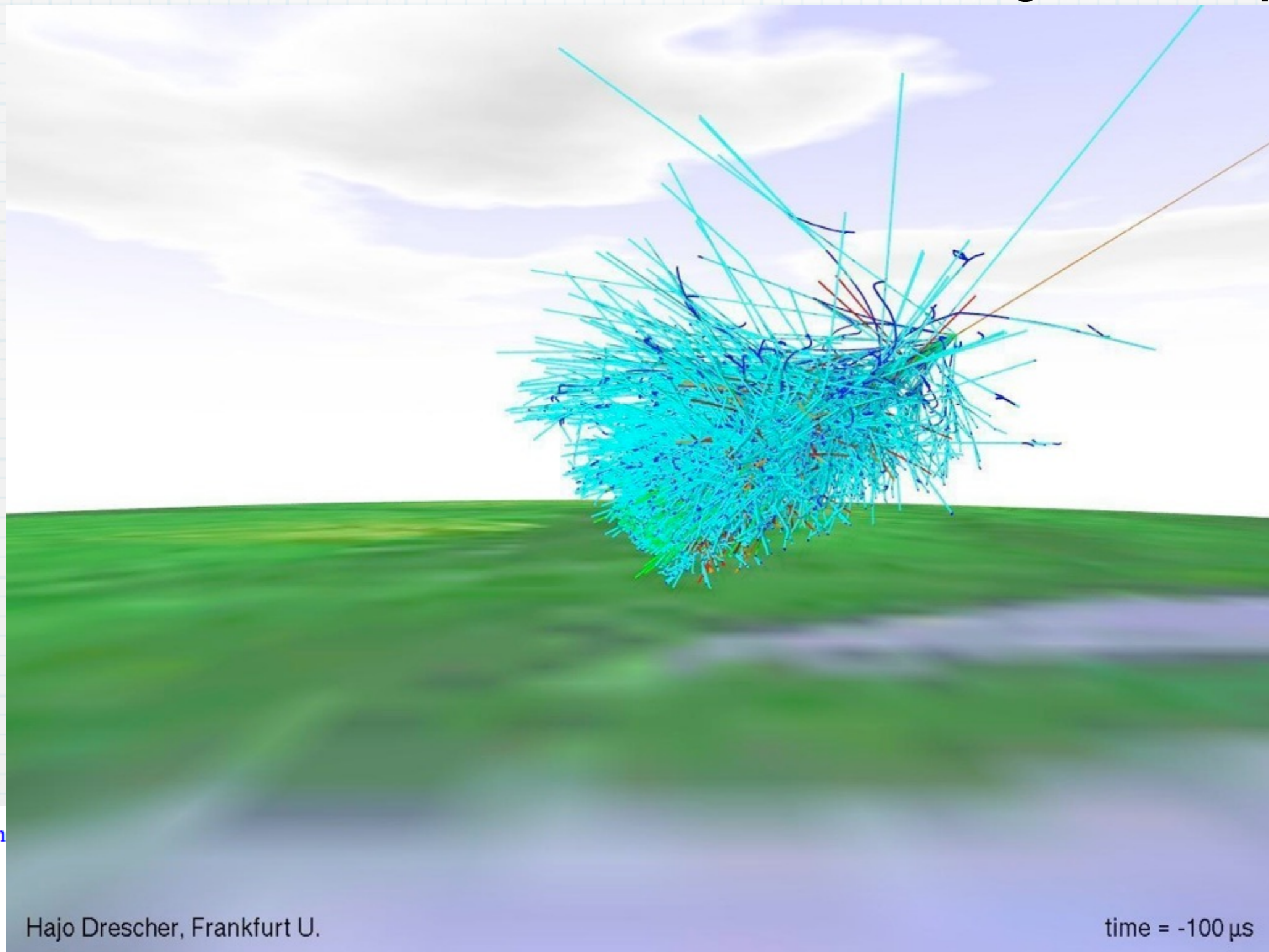
3. Die Teilchen dieser Welt und ihre Eigenschaften

I. Die endliche Lebensdauer von Teilchen - ein alltägliches Beispiel



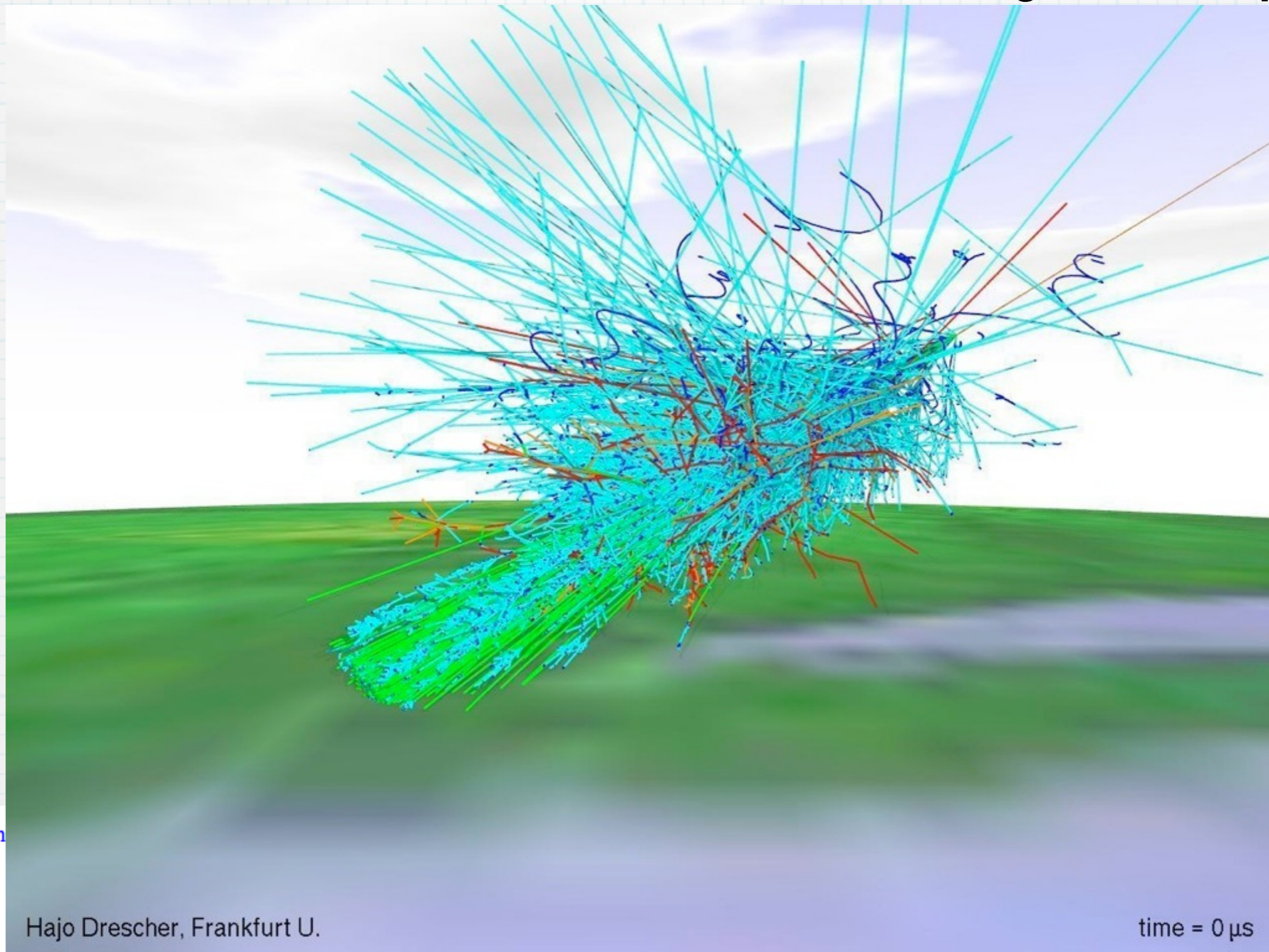
3. Die Teilchen dieser Welt und ihre Eigenschaften

I. Die endliche Lebensdauer von Teilchen - ein alltägliches Beispiel



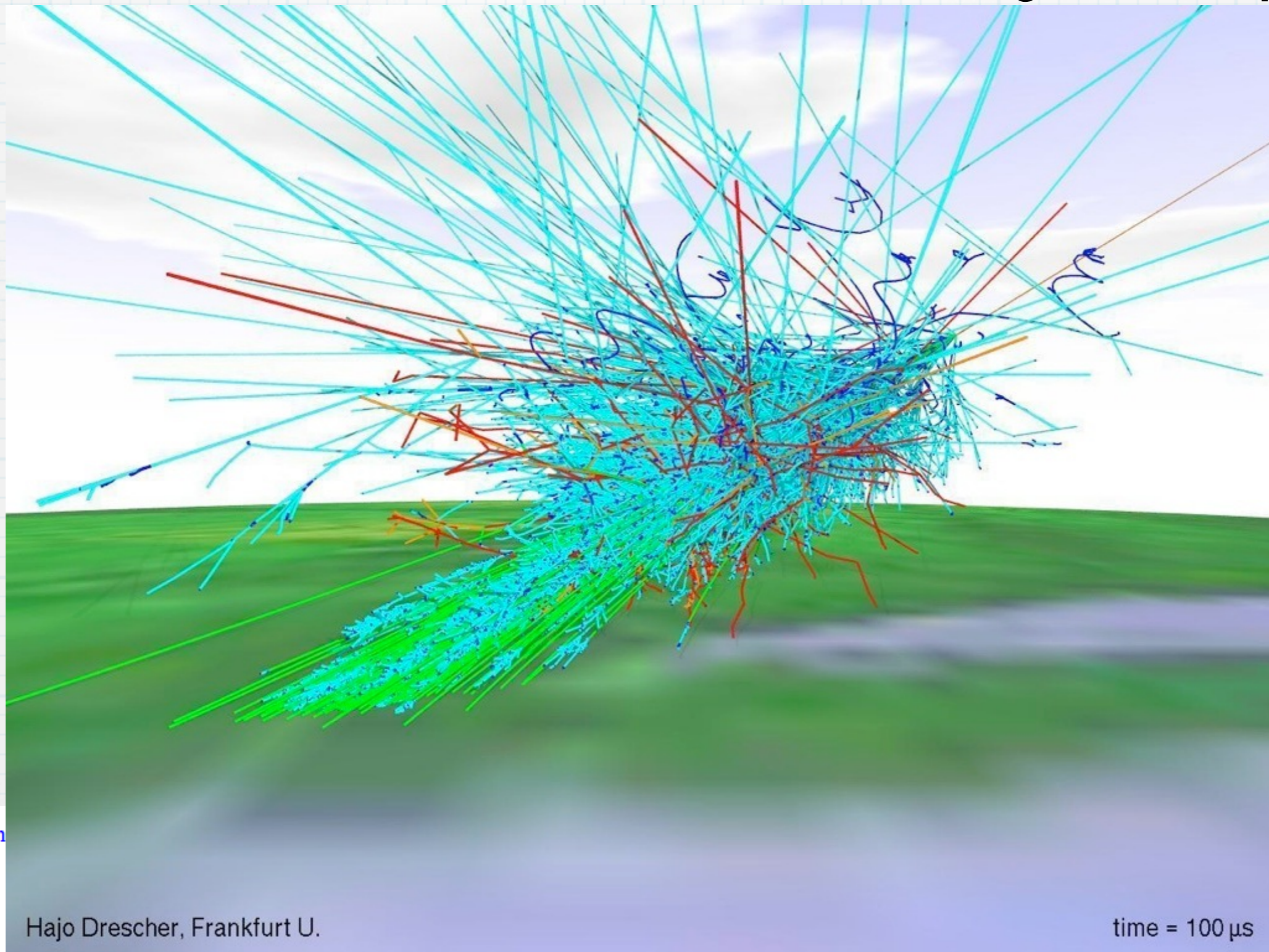
3. Die Teilchen dieser Welt und ihre Eigenschaften

I. Die endliche Lebensdauer von Teilchen - ein alltägliches Beispiel



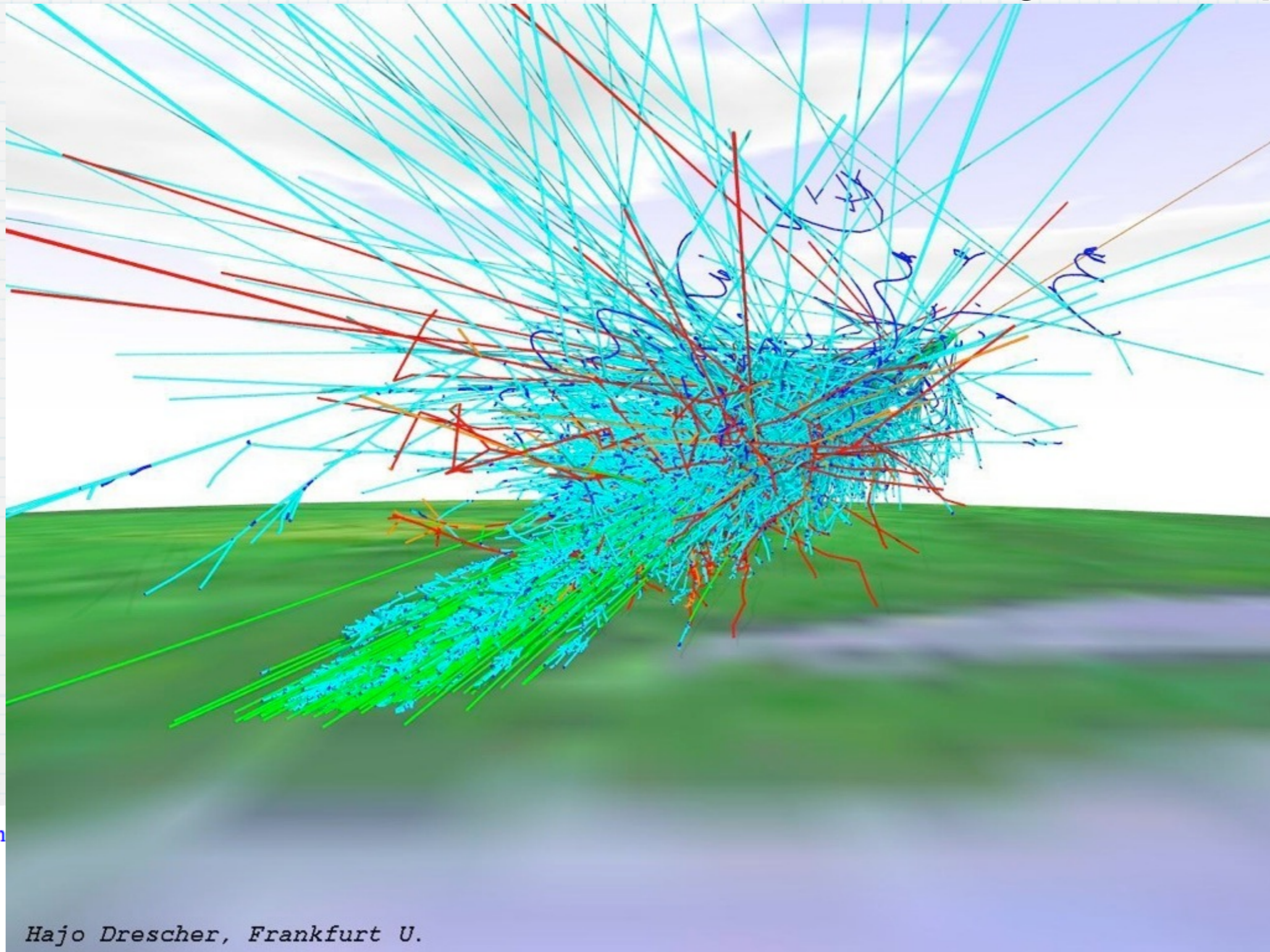
3. Die Teilchen dieser Welt und ihre Eigenschaften

I. Die endliche Lebensdauer von Teilchen - ein alltägliches Beispiel



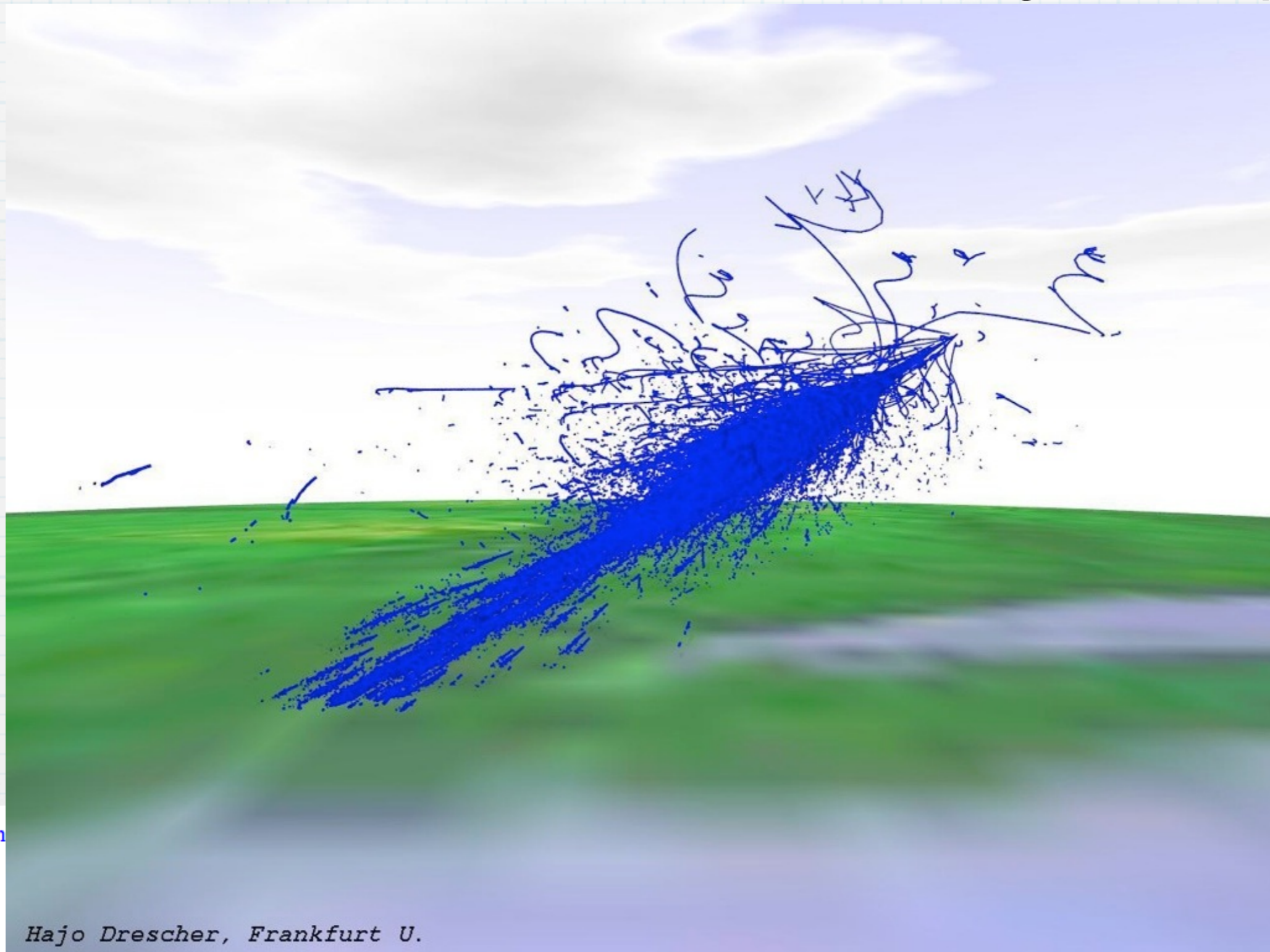
3. Die Teilchen dieser Welt und ihre Eigenschaften

I. Die endliche Lebensdauer von Teilchen - ein alltägliches Beispiel



3. Die Teilchen dieser Welt und ihre Eigenschaften

I. Die endliche Lebensdauer von Teilchen - ein alltägliches Beispiel

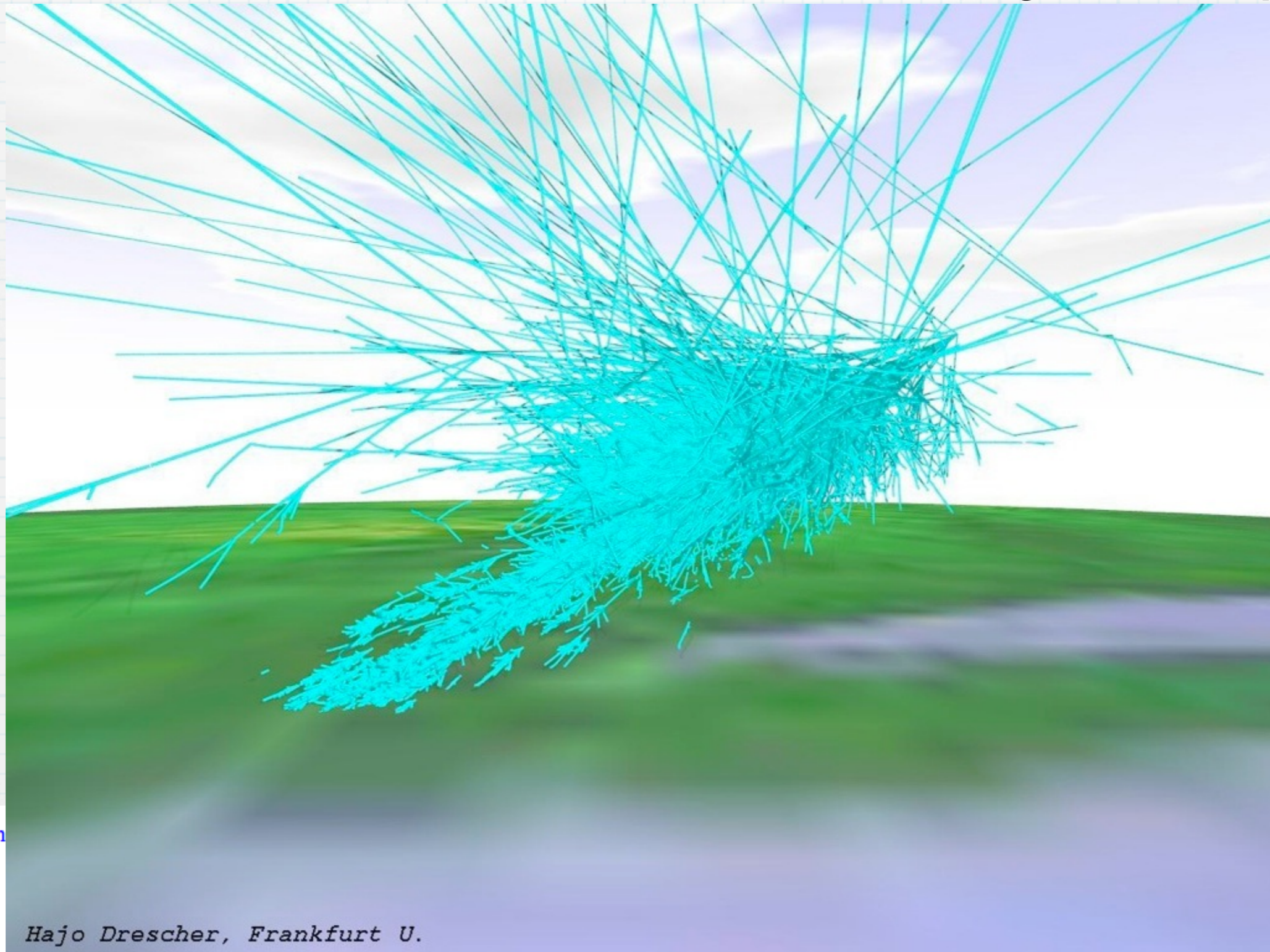


blue:electrons/positron
cyan:photons
red:neutrons
orange: protons
gray: mesons
green:muons

Hajo Drescher, Frankfurt U.

3. Die Teilchen dieser Welt und ihre Eigenschaften

I. Die endliche Lebensdauer von Teilchen - ein alltägliches Beispiel

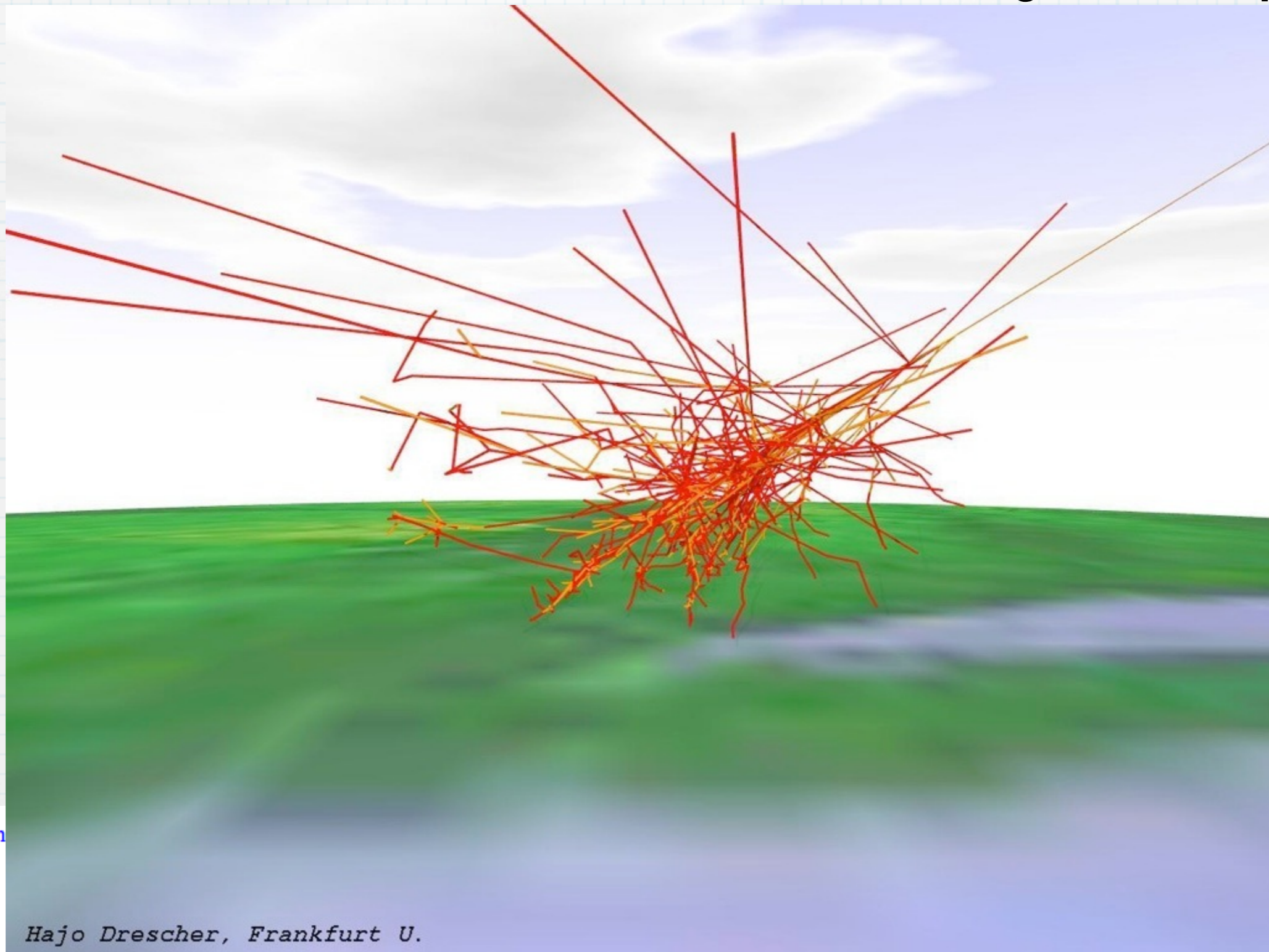


blue:electrons/positron
cyan:photons
red:neutrons
orange: protons
gray: mesons
green:muons

Hajo Drescher, Frankfurt U.

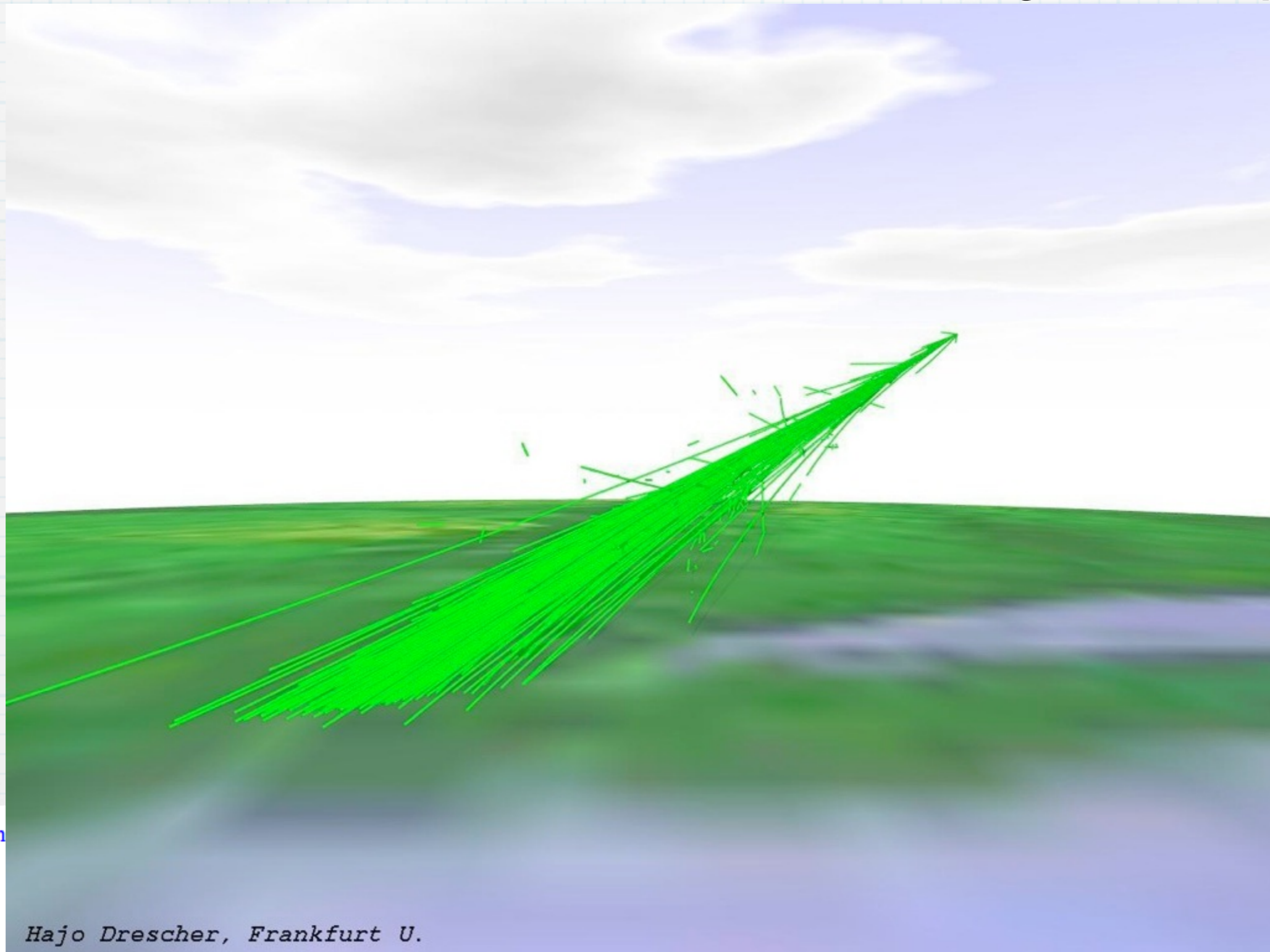
3. Die Teilchen dieser Welt und ihre Eigenschaften

I. Die endliche Lebensdauer von Teilchen - ein alltägliches Beispiel



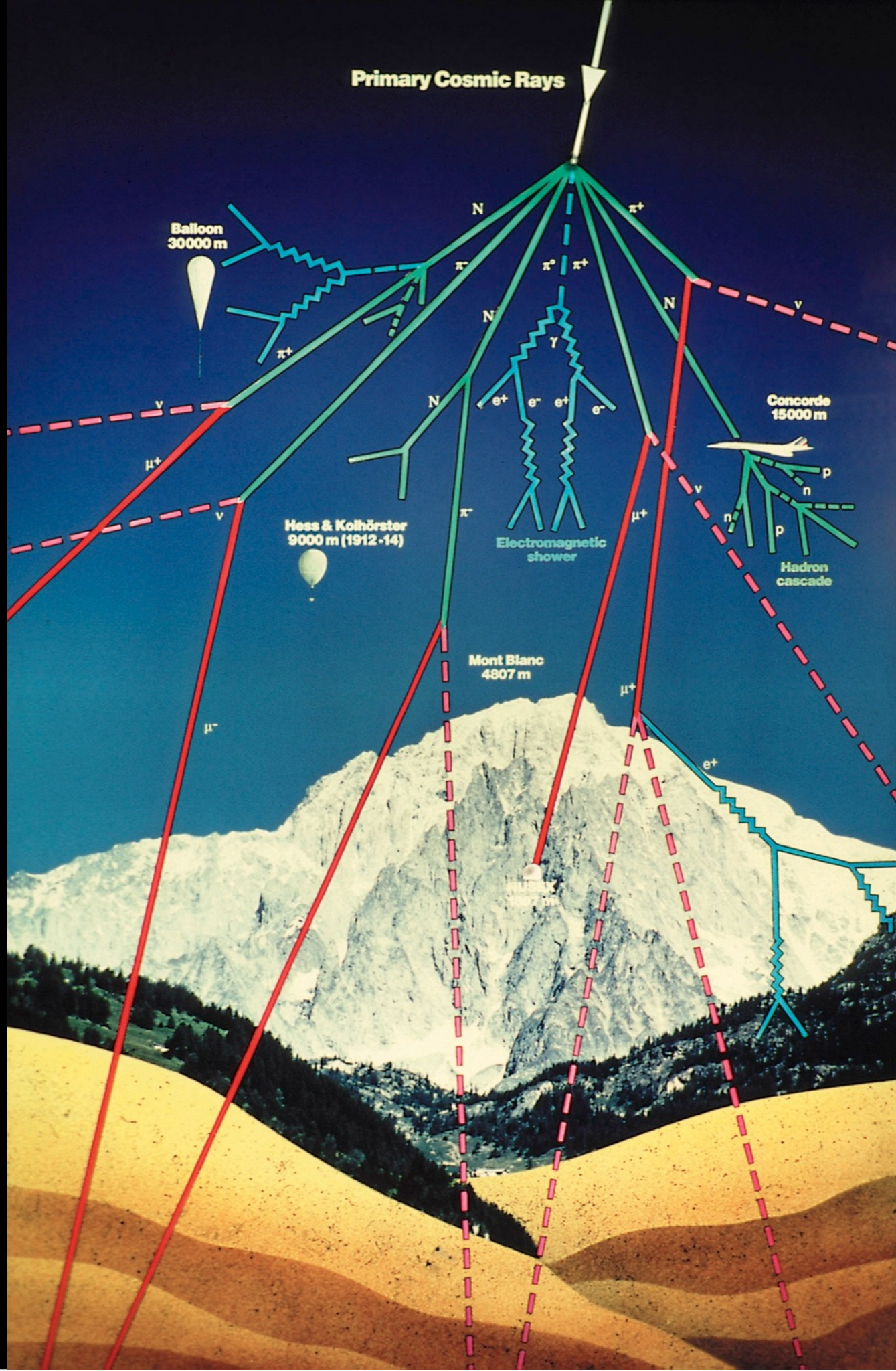
3. Die Teilchen dieser Welt und ihre Eigenschaften

I. Die endliche Lebensdauer von Teilchen - ein alltägliches Beispiel



blue:electrons/positron
cyan:photons
red:neutrons
orange: protons
gray: mesons
green:muons

Hajo Drescher, Frankfurt U.



High energy cosmic rays striking atoms at the top of the atmosphere give the rise to showers of particles striking the Earth's surface

Source: <http://cds.cern.ch/record/40407>

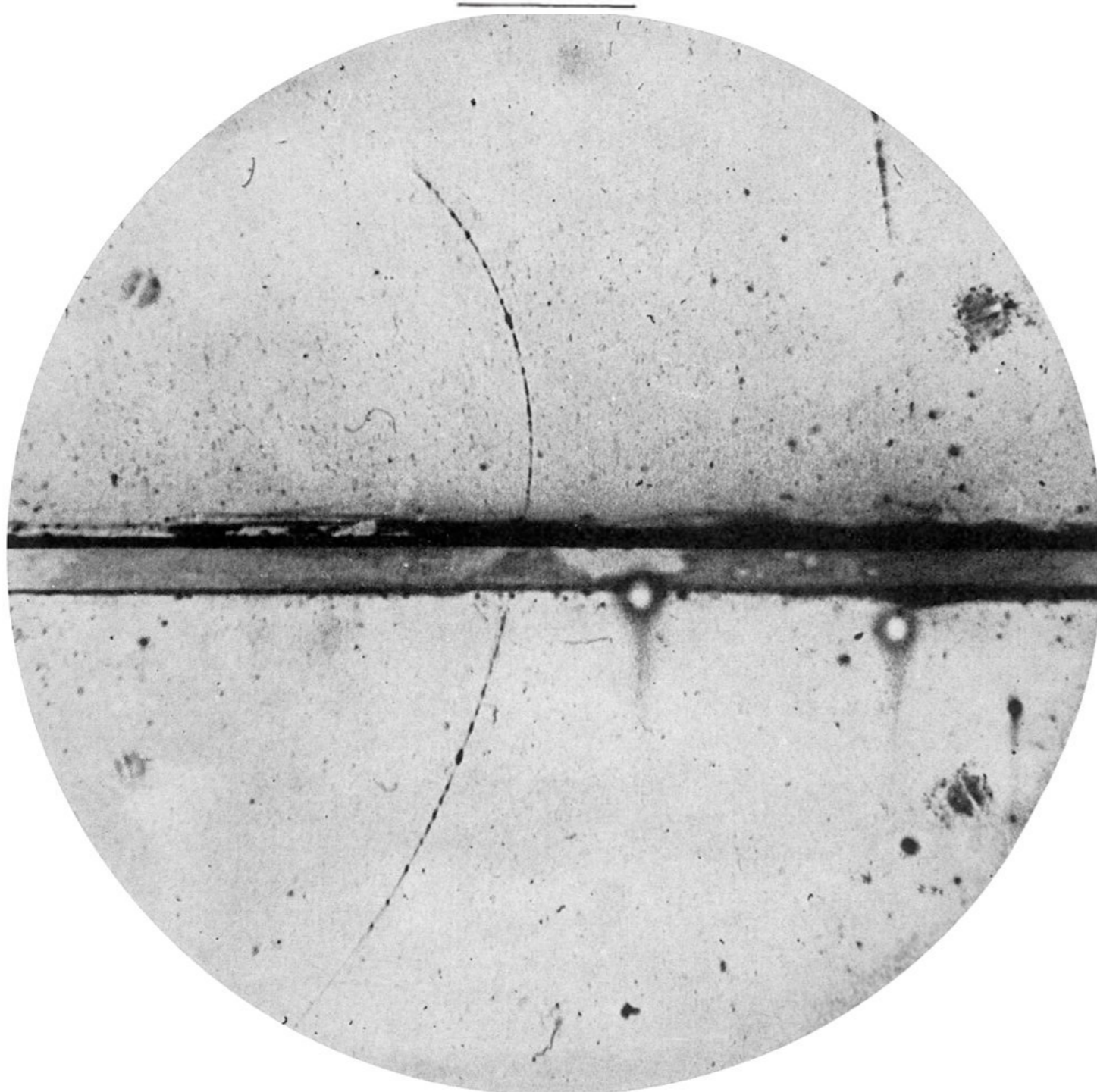
The Positive Electron

CARL D. ANDERSON, *California Institute of Technology, Pasadena, California*
(Received February 28, 1933)

Out of a group of 1300 photographs of cosmic-ray tracks in a vertical Wilson chamber 13 tracks were of positive particles which could not have a mass as great as that of the proton. From an examination of the energy-loss and ionization produced it is concluded that the charge is less than twice, and is probably exactly equal to, that of the proton. If these particles carry unit positive charge the

curvatures and ionizations produced require the mass to be less than twenty times the electron mass. These particles will be called positrons. Because they occur in groups associated with other tracks it is concluded that they must be secondary particles ejected from atomic nuclei.

Editor



Carl D. Anderson (1905–1991) - Anderson, Carl D. (1933). "The Positive Electron". *Physical Review* 43 (6): 491–494. [DOI:10.1103/PhysRev.43.491](https://doi.org/10.1103/PhysRev.43.491).

Cloud chamber photograph of the first **positron** ever observed Original caption: A 63 million volt positron passing through a 6 mm lead plate and emerging as a 23 million volt positron. The length of this latter path is at least ten times greater than the possible length of a proton path of this curvature.

Further experiments at CERN



ATLAS collision point

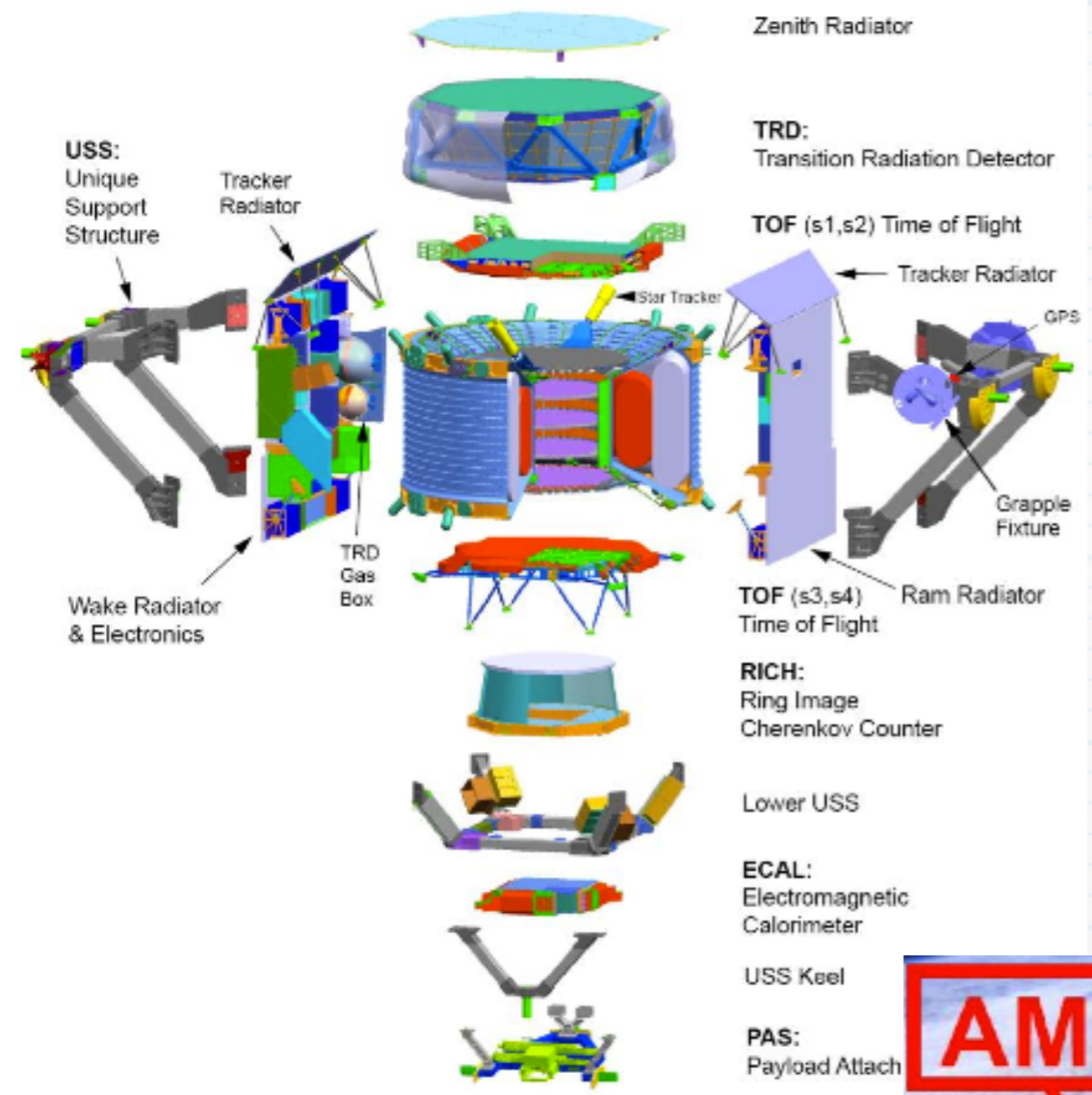
LHCf detector 2

LHCf detector 1

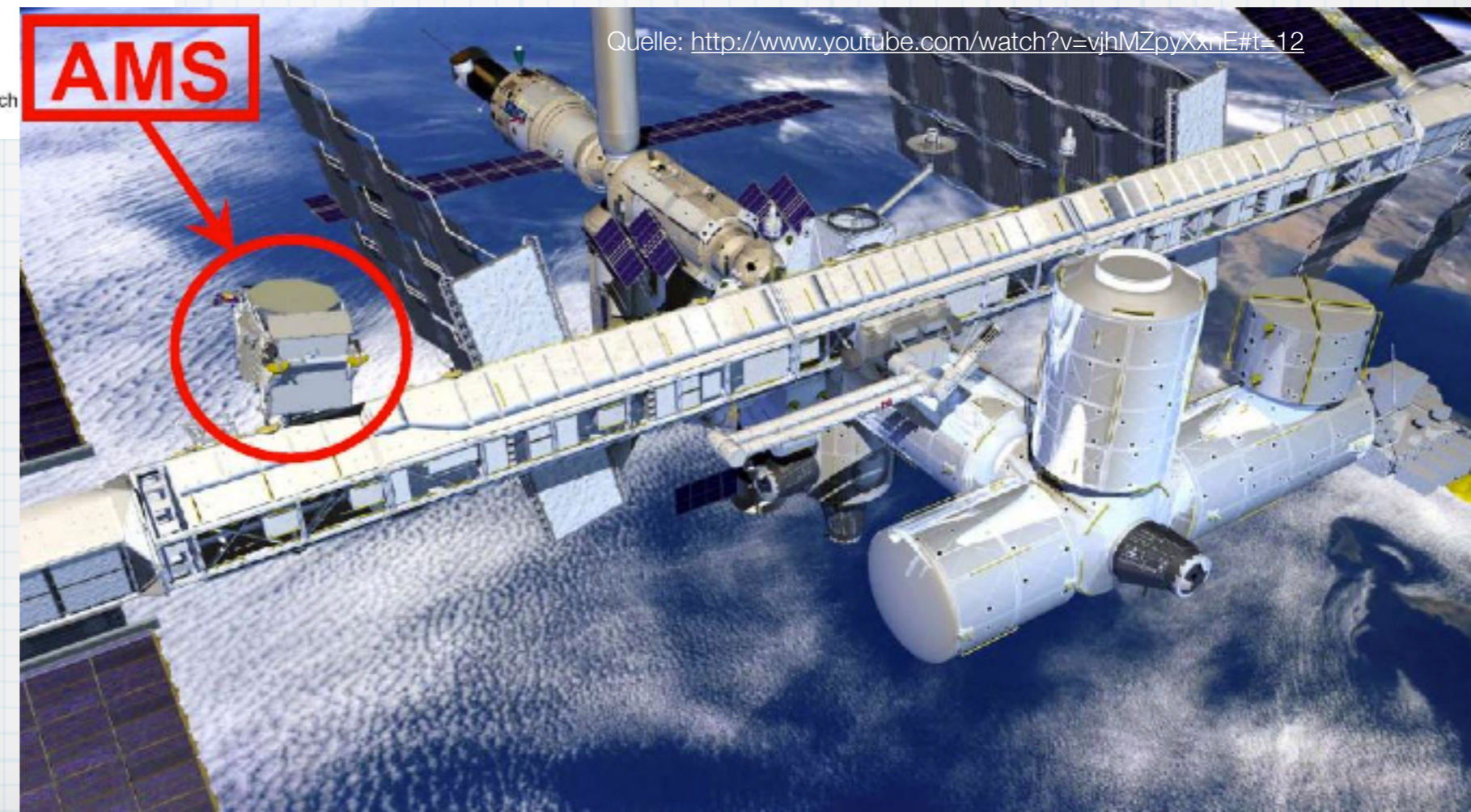
Neutral secondary particles

LHCf experiment at LHC - small (length: 30cm, mass: 70kg) but effective

Source: <http://cds.cern.ch/record/1518935/files/CERN-Brochure-2012-008-Eng.pdf>



Video auf Folie 10: "STS 134 Space Shuttle Endeavour AMS 02 Install timelapse"
 © 2013 AMS-02. All right reserved.



Quelle: <http://www.youtube.com/watch?v=vjhMZpyXxiE#t=12>

5. Observations 3

Tasks:

Observe with your cloud chamber.

Describe (shape, length, width, ...) which tracks you see.

Guess which particles create which tracks.

Further Readings

C. T. R. WILSON: On an Expansion Apparatus for Making Visible the Tracks of Ionising Particles in Gases and Some Results Obtained by Its Use. Proc. R. Soc. Lond. A. 1912 87 277-292 doi:10.1098/rspa.1912.0081 (published 19 September 1912)

Credits

CERN Cloud chamber workshop developed by:

D. BERTOLA , M. CIRILLI , J. FLAMMER , G.
SCHLAGER , S.
SCHUH , P. SCHUNE , M. STORR

Konrad Jende - konrad.jende@cern.ch

33-R-010 +41 76 487 0246

6. Another chamber ...

If you are able to spend 23.000 CHF ... but have a look.

Konrad Jende - konrad.jende@cem.ch

33-R-010 +41 76 487 0246